

Form PTO-1390  
(REV 10-2000)

U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

ATTORNEY'S DOCKET NUMBER

TRANSMITTAL LETTER TO THE UNITED STATES  
DESIGNATED/ELECTED OFFICE (DO/EO/US)  
CONCERNING A FILING UNDER 35 U.S.C. 371

1581.0870000/RWE/MTT

U.S. APPLICATION NO. (IF KNOWN, SEE 37 C.F.R. § 1.5)

To be assigned 937484

INTERNATIONAL APPLICATION NO

PCT/GB00/01247

INTERNATIONAL FILING DATE

31 March 2000

PRIORITY DATE CLAIMED

31 March 1999

TITLE OF INVENTION

Use of a Lectin or Conjugates for Modulation of C-Fibre Activity

APPLICANT(S) FOR DO/EO/US

FOSTER, Keith Alan; CHADDUCK, John Andrew; QUINN, Conrad Padraig

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This is an express request to begin national examination procedures (35 U.S.C. 371(f)).
4. ☒ The US has been elected by the expiration of 19 months from the priority date (PCT Article 31).
5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
  - a. ☐ is attached hereto (required only if not communicated by the International Bureau).
  - b. ☒ has been communicated by the International Bureau.
  - c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☐ An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
7. ☐ Amendments to the claims of the International application under PCT Article 19 (35 U.S.C. 371(c)(3))
  - a. ☐ are attached hereto (required only if not communicated by the International Bureau).
  - b. ☐ have been communicated by the International Bureau.
  - c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
  - d. ☐ have not been made and will not be made.
8. ☐ An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 372(c)(3)).
9. ☐ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ An English language translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

## Items 11. to 16. below concern other document(s) or information included:

11. ☒ An Information Disclosure Statement under 37 C.F.R. 1.97 and 1.98 with 6 pages of Form PTO-1449 and 23 cited documents.
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 C.F.R. 3.28 and 3.31 is included.
13. ☒ A **FIRST** preliminary amendment.  
☐ A **SECOND** or **SUBSEQUENT** preliminary amendment.
14. ☐ A substitute specification.
15. ☐ A change of power of attorney and/or address letter.
16. ☒ Other items or information:
  - a) A copy of published International Application No. PCT/GB00/01247 including 39 pages of description prior to the claims, 4 pages of claims (claims 1-32), and 13 sheets of drawings (Figs. 1-14);
  - b) Form PCT/IPEA/416;
  - c) Form PCT/IPEA/409 with annexes;
  - d) Application Data Sheet;
  - e) Authorization To Treat A Reply As Incorporating An Extension Of Time Under 37 C.F.R. § 1.136(a)(3) (in duplicate); and
  - f) Two (2) return postcards.

U.S. APPLICATION NO. (if known, see 37 C.F.R. 1.50) To be assigned <b>09/937484</b>	INTERNATIONAL APPLICATION NO <b>PCT/GB00/01247</b>	ATTORNEY'S DOCKET NUMBER <b>1581.0870000/RWE/MTT</b>
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17. <input checked="" type="checkbox"/> The following fees are submitted:  <b>Basic National Fee (37 CFR 1.492(a)(1)-(5)):</b> Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO ..... <b>\$1000.00</b>  International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO ..... <b>\$860.00</b>  International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO ..... <b>\$710.00</b>  International preliminary examination fee paid to USPTO (37 CFR 1.482) but all claims did not satisfy provisions of PCT Article 33(1)-(4) ..... <b>\$690.00</b>  International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4) ..... <b>\$ 100.00</b>  <div style="text-align: right;"><b>ENTER APPROPRIATE BASIC FEE AMOUNT = \$ 860.00</b></div>	<b>CALCULATIONS      PTO USE ONLY</b>																																																																														
Surcharge of <b>\$130.00</b> for furnishing the oath or declaration later than <input type="checkbox"/> 20 <input checked="" type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492(e)).	<b>\$ 130.00</b>																																																																														
<table border="1" style="width:100%; border-collapse: collapse;"> <thead> <tr> <th style="width:20%;">Claims</th> <th style="width:15%;">Number Filed</th> <th style="width:15%;">Number Extra</th> <th style="width:15%;">Rate</th> <th style="width:15%;"></th> <th style="width:20%;"></th> </tr> </thead> <tbody> <tr> <td>Total Claims</td> <td>19 - 20 =</td> <td>0</td> <td>X \$18.00</td> <td>\$ 00.00</td> <td></td> </tr> <tr> <td>Independent Claims</td> <td>2 - 3 =</td> <td>0</td> <td>X \$80.00</td> <td>\$ 00.00</td> <td></td> </tr> <tr> <td colspan="3">Multiple dependent claim(s) (if applicable)</td> <td>+ \$270.00</td> <td>\$ 270.00</td> <td></td> </tr> <tr> <td colspan="4" style="text-align: right;"><b>TOTAL OF ABOVE CALCULATIONS =</b></td> <td>\$1260.00</td> <td></td> </tr> <tr> <td colspan="4"> <input type="checkbox"/> Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2.         </td> <td>\$</td> <td></td> </tr> <tr> <td colspan="4" style="text-align: right;"><b>SUBTOTAL =</b></td> <td>\$1260.00</td> <td></td> </tr> <tr> <td colspan="4">           Processing fee of \$130.00 for furnishing the English translation later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the            earliest claimed priority date (37 CFR 1.492(f)).         </td> <td>\$</td> <td></td> </tr> <tr> <td colspan="4" style="text-align: right;"><b>TOTAL NATIONAL FEE =</b></td> <td>\$1260.00</td> <td></td> </tr> <tr> <td colspan="4">           Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by            an appropriate cover sheet (37 CFR 3.28, 3.31). <b>\$40.00</b> per property         </td> <td>\$</td> <td></td> </tr> <tr> <td colspan="4" style="text-align: right;"><b>TOTAL FEES ENCLOSED =</b></td> <td>\$1260.00</td> <td></td> </tr> <tr> <td colspan="4"></td> <td style="text-align: right;"><b>Amount to be refunded:</b></td> <td>\$</td> </tr> <tr> <td colspan="4"></td> <td style="text-align: right;"><b>charged:</b></td> <td>\$</td> </tr> </tbody> </table>	Claims	Number Filed	Number Extra	Rate			Total Claims	19 - 20 =	0	X \$18.00	\$ 00.00		Independent Claims	2 - 3 =	0	X \$80.00	\$ 00.00		Multiple dependent claim(s) (if applicable)			+ \$270.00	\$ 270.00		<b>TOTAL OF ABOVE CALCULATIONS =</b>				\$1260.00		<input type="checkbox"/> Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2.				\$		<b>SUBTOTAL =</b>				\$1260.00		Processing fee of \$130.00 for furnishing the English translation later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492(f)).				\$		<b>TOTAL NATIONAL FEE =</b>				\$1260.00		Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). <b>\$40.00</b> per property				\$		<b>TOTAL FEES ENCLOSED =</b>				\$1260.00						<b>Amount to be refunded:</b>	\$					<b>charged:</b>	\$	
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a. ☒ A check in the amount of \$ 1260.00 to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. \_\_\_\_\_ in the amount of \$ \_\_\_\_\_ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 19-0036. A duplicate copy of this sheet is enclosed.

**NOTE: Where an appropriate time limit Under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.**

SEND ALL CORRESPONDENCE TO: <b>STERNE, KESSLER, GOLDSTEIN &amp; FOX P.L.L.C.</b> 1100 New York Avenue, NW, Suite 600 Washington, D.C. 20005-3934	<div style="text-align: right;">           _____  <small>SIGNATURE</small> </div> <div style="text-align: right;"> <u>Sept. 26, 2001</u>          _____  <small>DATE</small> </div> <div style="text-align: right;"> <b>Robert W. Esmond</b>          _____  <small>NAME</small> </div> <div style="text-align: right;"> <u>32,893</u>          _____  <small>REGISTRATION NUMBER</small> </div>
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09/937484

J003 Rec'd PCT/TO 26 SEP 2001

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of:

Foster *et al.*

Appl. No. (U.S. Natl. Phase of  
PCT/GB00/01247)

Filed: (Int. Filing Date: March 31, 2000)

For: **Use of a Lectin or Conjugates for  
Modulation of C-Fibre Activity**

Confirmation No.: *To be assigned*

Art Unit: *To be assigned*

Examiner: *To be assigned*

Atty. Docket: 1581.0870000/RWE/MTT

**Preliminary Amendment**

Commissioner for Patents  
Washington, D.C. 20231

Sir:

In advance of prosecution of the captioned application, Applicants submit the following Preliminary Amendments and Remarks. This Preliminary Amendment is provided in the following format:

- (A) A clean version of each replacement paragraph/section/claim along with clear instructions for entry;
- (B) Starting on a separate page, appropriate remarks and arguments.  
37 C.F.R. § 1.121 and MPEP 714; and
- (C) Starting on a separate page, a marked-up version entitled: "Version with markings to show changes made."

It is not believed that extensions of time or fees for net addition of claims are required beyond those that may otherwise be provided for in documents accompanying this paper. However, if additional extensions of time are necessary to prevent abandonment of this application, then such extensions of time are hereby petitioned under 37 C.F.R.

§ 1.136(a), and any fees required therefor (including fees for net addition of claims) are hereby authorized to be charged to our Deposit Account No. 19-0036.

***Amendments***

Please amend the application as follows:

***In the Specification:***

In the specification at page 1, before line 1, please insert the following paragraph:

The present application is a 371 of PCT/GB00/01247 filed on March 31, 2000, and published in English on October 5, 2000, the disclosure of which is incorporated herein by reference in its entirety.

***In the Abstract:***

Please insert following abstract on page 44 after the claims:

The present invention relates to the treatment of pain and to compounds that modulate C-fibre activity. In particular, the present invention relates to the use of a lectin in the manufacture of a medicament for modulation of C-fibre neuron activity, and to lectin conjugates. The lectin conjugates comprise a lectin coupled to a peptide or protein, wherein the peptide or protein is substantially free of Clostridial neurotoxin enzyme activity. The present invention also concerns methods for manufacturing conjugates. The compounds and compositions described have particular application in the treatment of diseases of which C-fibre activity is a component. Such diseases include pain, inflammation, psoriasis and other C-fibre related conditions.

This abstract is provided on a separate sheet appended hereto.

***In the Claims:***



Please amend the claims (attached as annexes to the International Preliminary Examination Report filed herewith) as follows:

Please cancel claims 1-29 without prejudice to or disclaimer of the subject matter contained therein. Applicants reserve the right to prosecute the subject matter of these claims in one or more continuing applications.

Please add the following new claims:

30. (New) A conjugate comprising a first lectin coupled to a peptide or protein, wherein said first lectin is non-endogenous to humans, and wherein said peptide or protein is substantially free of Clostridial neurotoxin enzyme activity.

31. (New) A conjugate according to Claim 30 wherein the peptide or protein is a second lectin.

32. (New) A conjugate according to Claim 30 wherein the first lectin binds to a galactosyl residue.

33. (New) A conjugate according to Claim 30 wherein the first lectin binds to a glucosyl residue.

34. (New) A conjugate according to Claim 31 wherein the first and second lectins are different.

35. (New) A conjugate according to Claim 34 wherein the first lectin binds to a galactosyl residue and the second lectin binds to a glucosyl residue.

36. (New) A conjugate according to Claim 30, wherein the peptide or protein is an endopeptidase, or a Clostridial neurotoxin substantially free of enzyme activity.

37. (New) A conjugate according to Claim 30, wherein the first lectin is a lectin derivative, said derivative having been modified to remove a carbohydrate group while maintaining the ability of the derivative to bind C-fibres.

38. (New) A nucleic acid sequence encoding the conjugate of Claim 30.

39. (New) A method of treating a disease or condition resulting from an inhibition or stimulation of C-fibre neuron activity, by modulating C-fibre activity, comprising administering an effective amount of a lectin, or a conjugate according to Claim 30, or a nucleic acid sequence according to Claim 38, to a patient.

40. (New) A method according to Claim 39 for inhibiting C-fibre activity.

41. (New) A method according to Claim 39 for stimulating C-fibre activity.

42. (New) A method according to Claim 39 wherein said disease or condition is selected from the group consisting of pain, psoriasis, inflammation and mucus hypersecretion.

43. (New) A method of preparing a conjugate according to Claim 30, comprising coupling together, optionally via a linker, the first lectin and the peptide or protein.

44. (New) A method of preparing a conjugate according to Claim 30, comprising expressing in a host cell a nucleic acid sequence according to Claim 38, optionally including a linker nucleic acid sequence located within said nucleic acid sequence provides a linker molecule between the first lectin and the peptide or protein of the conjugate.

45. (New) A composition comprising a lectin and a peptide or protein, wherein the peptide or protein is an endopeptidase or a Clostridial neurotoxin free of enzyme activity.

46. (New) A composition according to Claim 45, wherein the peptide or protein is an LH<sub>N</sub> fragment of a Clostridial neurotoxin.

47. (New) A method of treating a disease or condition resulting from an inhibition or stimulation of C-fibre neuron activity, by modulating C-fibre activity, comprising administering a composition according to Claim 45 to a patient.

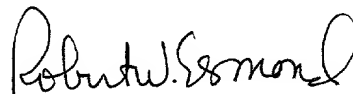
**Remarks**

By the foregoing amendments, claims 1-29 have been cancelled without prejudice or disclaimer. New claims 30-47 are sought to be entered. Support for the foregoing amendments to the claims may be found throughout the specification and in the claims as originally filed. Accordingly, the present amendments do not add new matter, and their entry is respectfully requested. Upon entry of the foregoing amendments, claims 30-47 are pending in the application, with claims 30 and 45 being the independent claims.

It is believed that the present application is in condition for immediate examination. If the Examiner believes, for any reason, that personal communication will expedite prosecution of this application, the Examiner is invited to telephone the undersigned at the number provided

Respectfully submitted,

STERNE, KESSLER, GOLDSTEIN & FOX P.L.L.C.



Robert W. Esmond  
Attorney for Applicants  
Registration No. 32,893

Date: Sept. 26, 2001

1100 New York Avenue, N.W.  
Suite 600  
Washington, D.C. 20005-3934  
(202) 371-2600

**Version with markings to show changes made**

**In the Specification:**

In the specification at page 1, before line 1, please insert the following paragraph:

The present application is a 371 of PCT/GB00/01247 filed on March 31, 2000, and published in English on October 5, 2000, the disclosure of which is incorporated herein by reference in its entirety.

***In the Abstract:***

Please insert following abstract on page 44 after the claims:

The present invention relates to the treatment of pain and to compounds that modulate C-fibre activity. In particular, the present invention relates to the use of a lectin in the manufacture of a medicament for modulation of C-fibre neuron activity, and to lectin conjugates. The lectin conjugates comprise a lectin coupled to a peptide or protein, wherein the peptide or protein is substantially free of Clostridial neurotoxin enzyme activity. The present invention also concerns methods for manufacturing conjugates. The compounds and compositions described have particular application in the treatment of diseases of which C-fibre activity is a component. Such diseases include pain, inflammation, psoriasis and other C-fibre related conditions.

***In the Claims:***

Claims 1-29 have been cancelled.

New claims 30-47 are sought to be entered.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of:

Foster *et al.*

Appl. No. 09/937,484

Int'l Filing Date: March 31, 2000

For: **Use of a Lectin or Conjugates for  
Modulation of C-Fibre Activity**

Confirmation No. 2134

Art Unit: *To be assigned*

Examiner: *To be assigned*

Atty. Docket: 1581.0870000/RWE/MTT

**Letter to PTO Draftsman: Submission of Formal Drawings**

Commissioner for Patents  
Washington, D.C. 20231

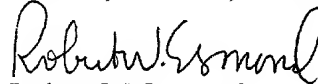
Sir:

Submitted herewith are fourteen (14) sheets of formal drawings with Figures 1-14, corresponding to the informal drawings submitted with the above-captioned application. Identification of the drawings is provided in accordance with 37 C.F.R. § 1.84(c). Acknowledgment of the receipt, approval, and entry of these formal drawings into this application is respectfully requested.

It is not believed that an extension of time is required, other than any already provided herewith. However, if an extension of time is needed to prevent abandonment of the application, then such extension of time is hereby petitioned. The U.S. Patent and Trademark Office is hereby authorized to charge any fee deficiency, or credit any overpayment, to our Deposit Account No. 19-0036. A duplicate copy of this Letter is enclosed.

Respectfully submitted,

STERNE, KESSLER, GOLDSTEIN & FOX P.L.L.C.



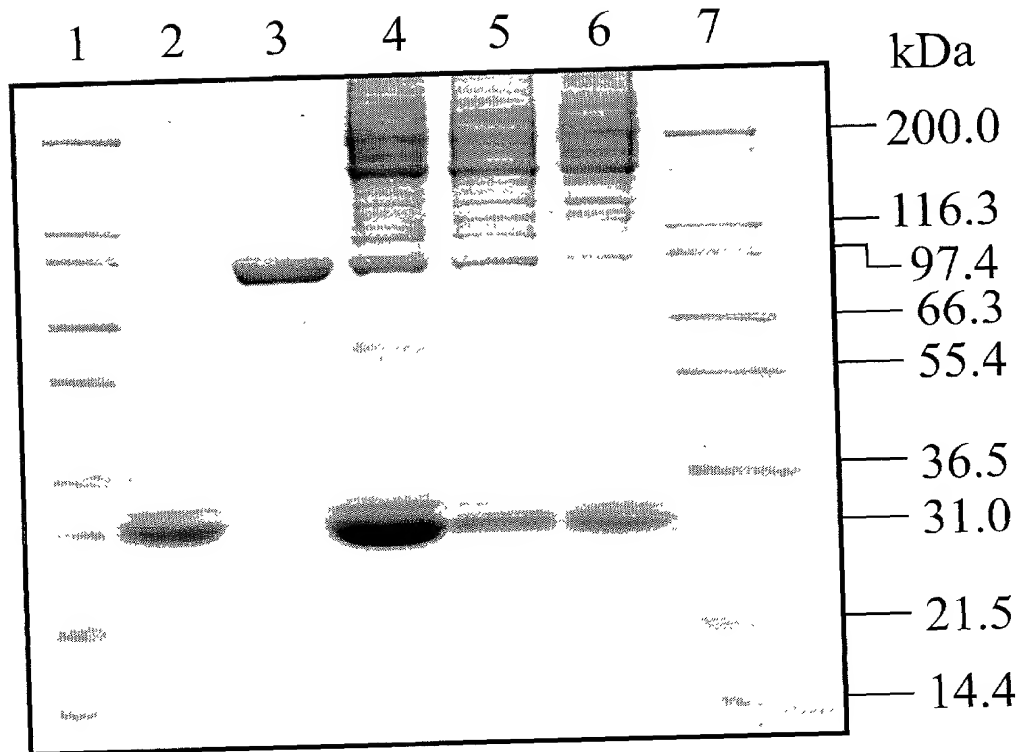
Robert W. Esmond  
Attorney for Applicants  
Registration No. 32,893

Date: Jan. 23, 2002

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Suite 600  
Washington, D.C. 20005-3934  
(202) 371-2600

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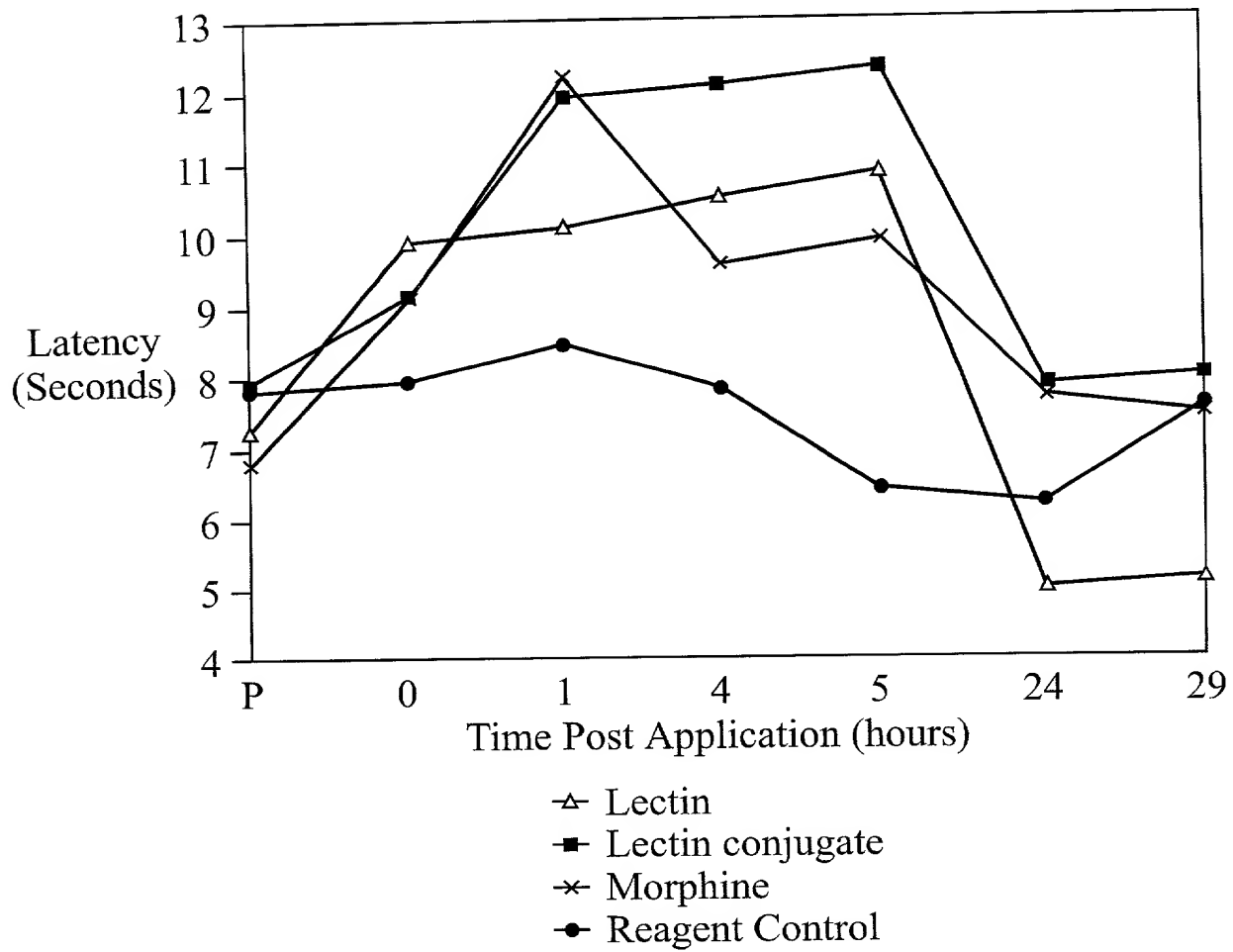
Fig. 1



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Fig. 2

Lectins and Lectin Conjugates are Analgesic in a  
Mouse Hot-plate Model

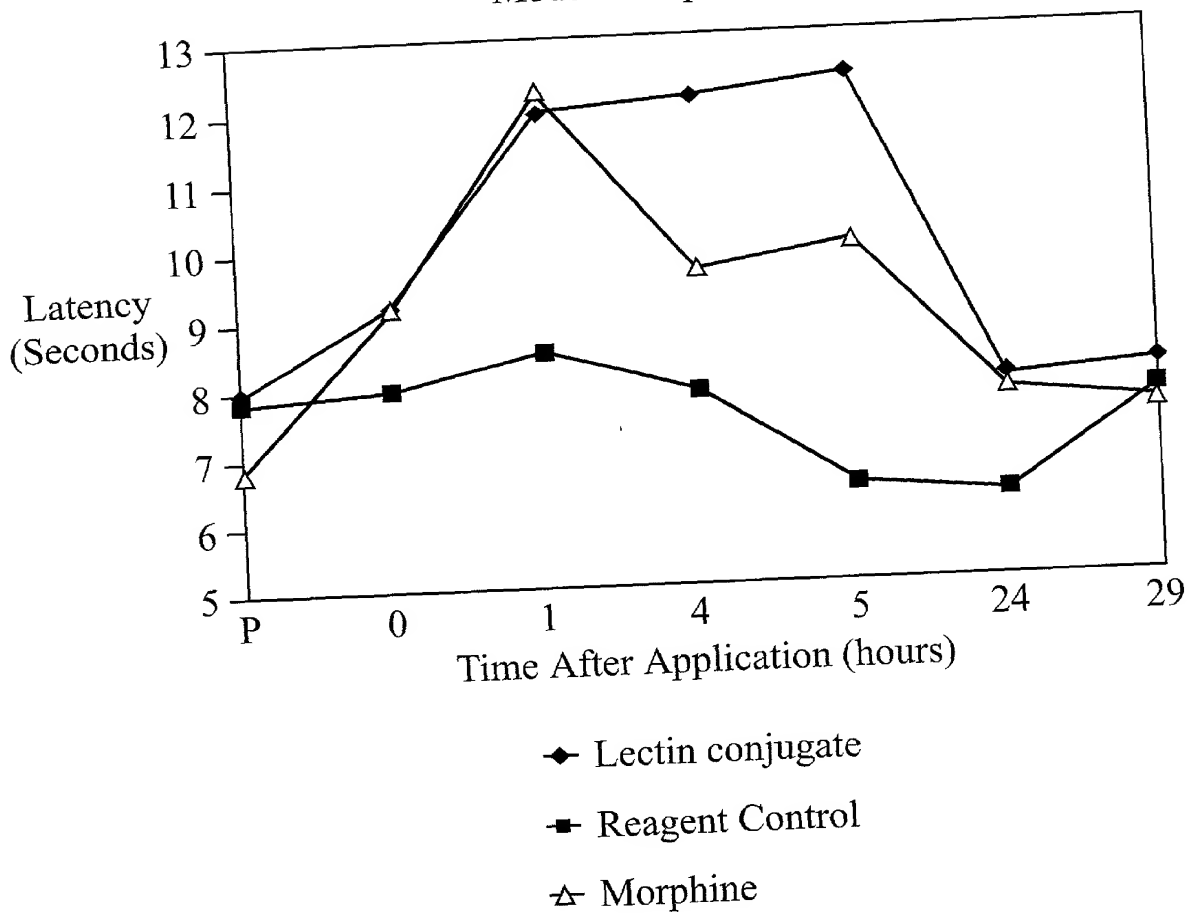




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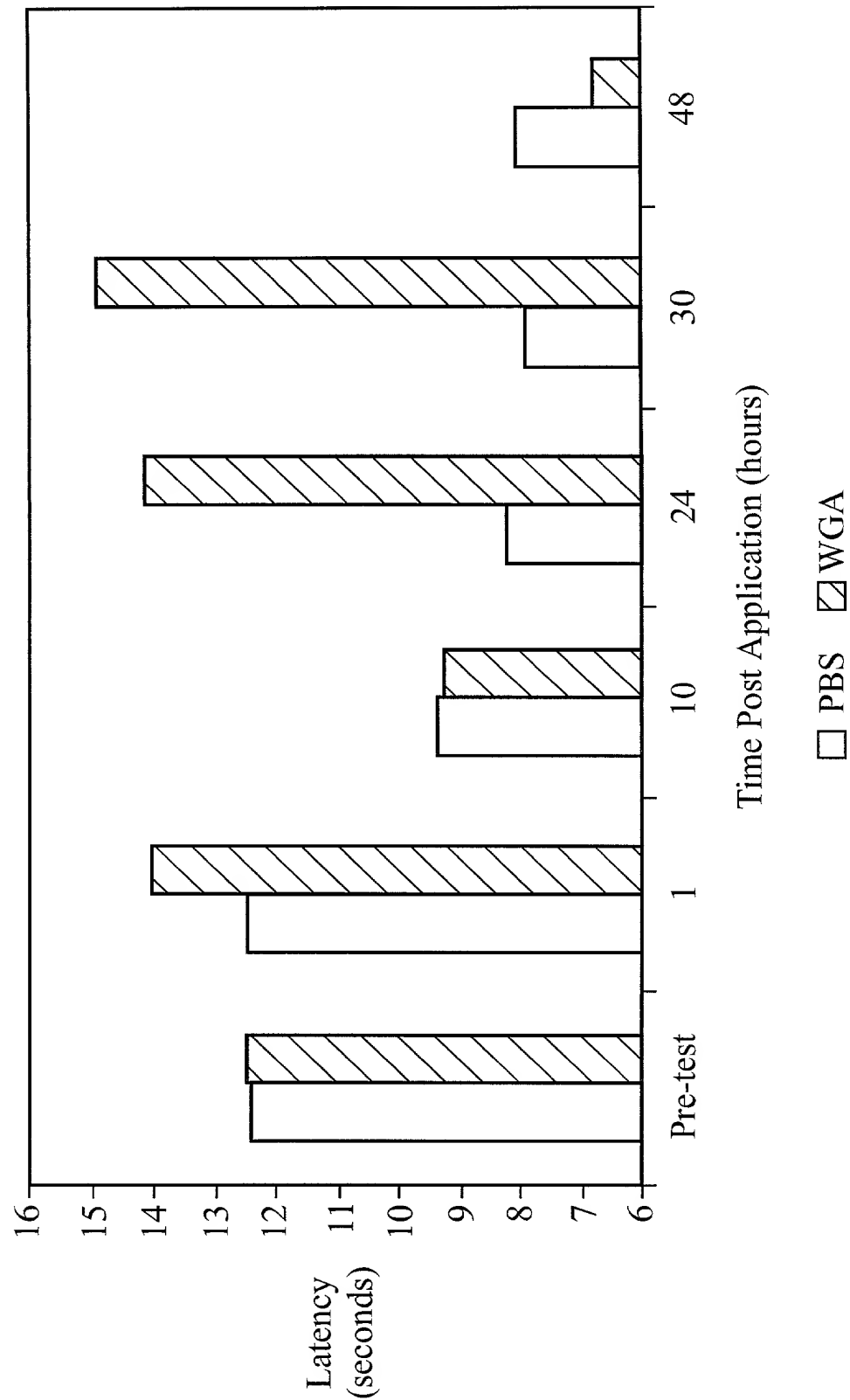
Fig. 3

ECL Lectin Conjugates are Analgesic in a  
Mouse Hot-plate Model



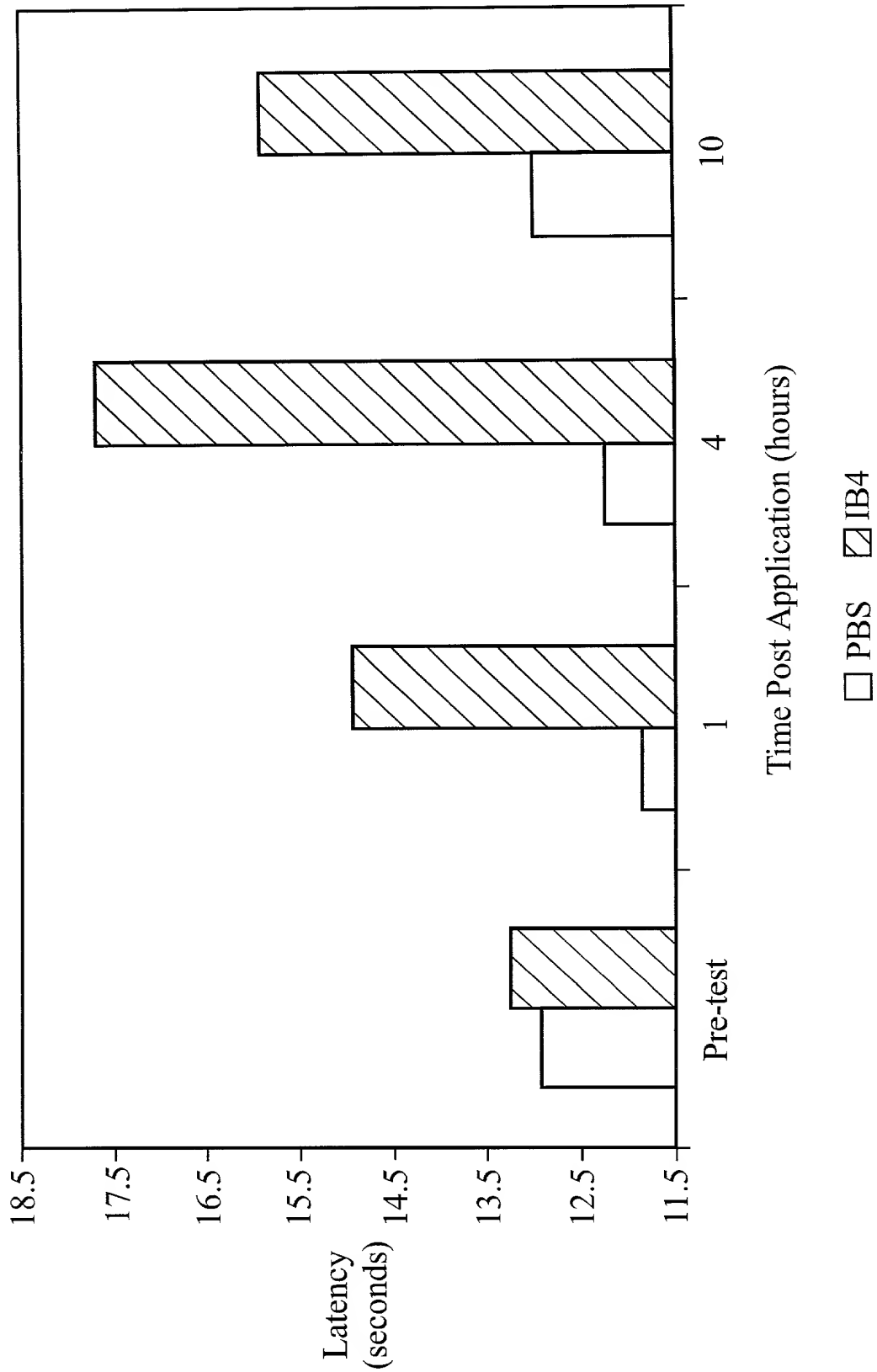
4/14

Fig. 4



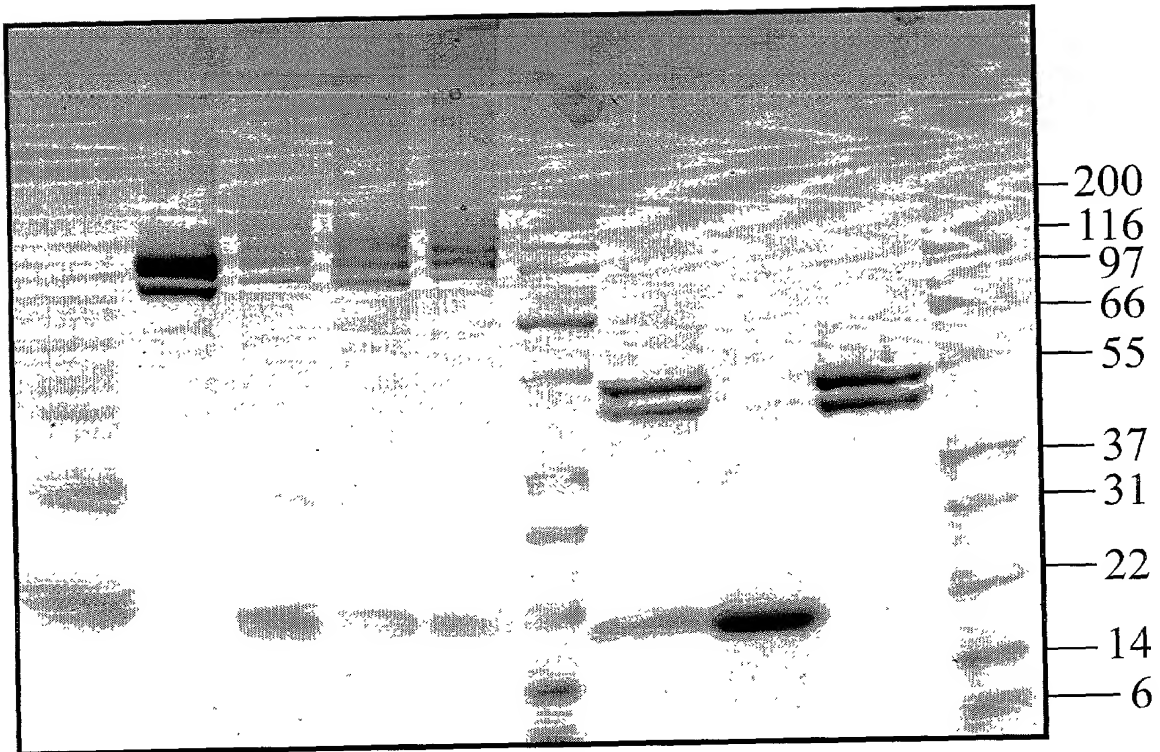
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Fig. 5



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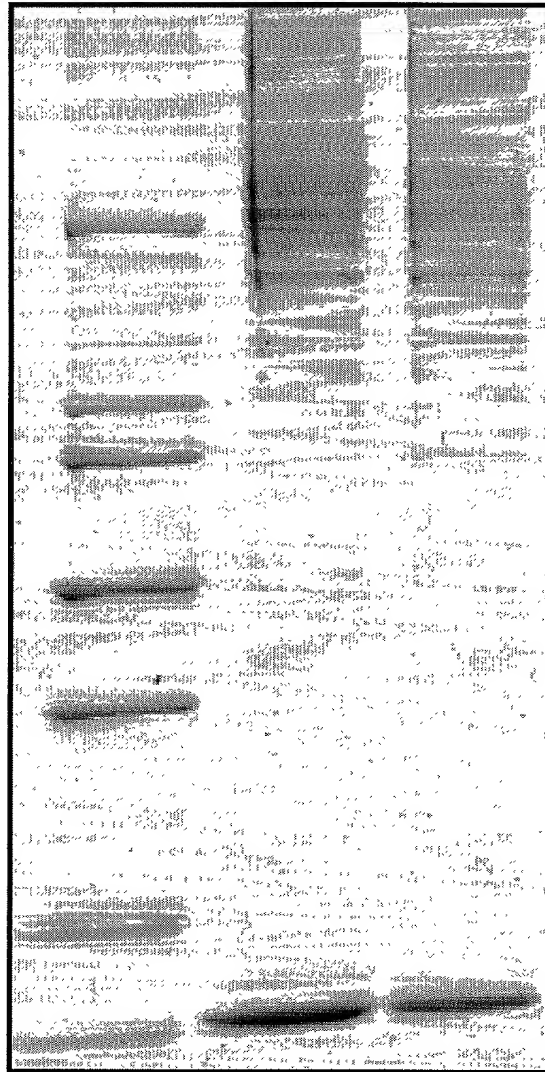
Fig. 6



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Fig. 7

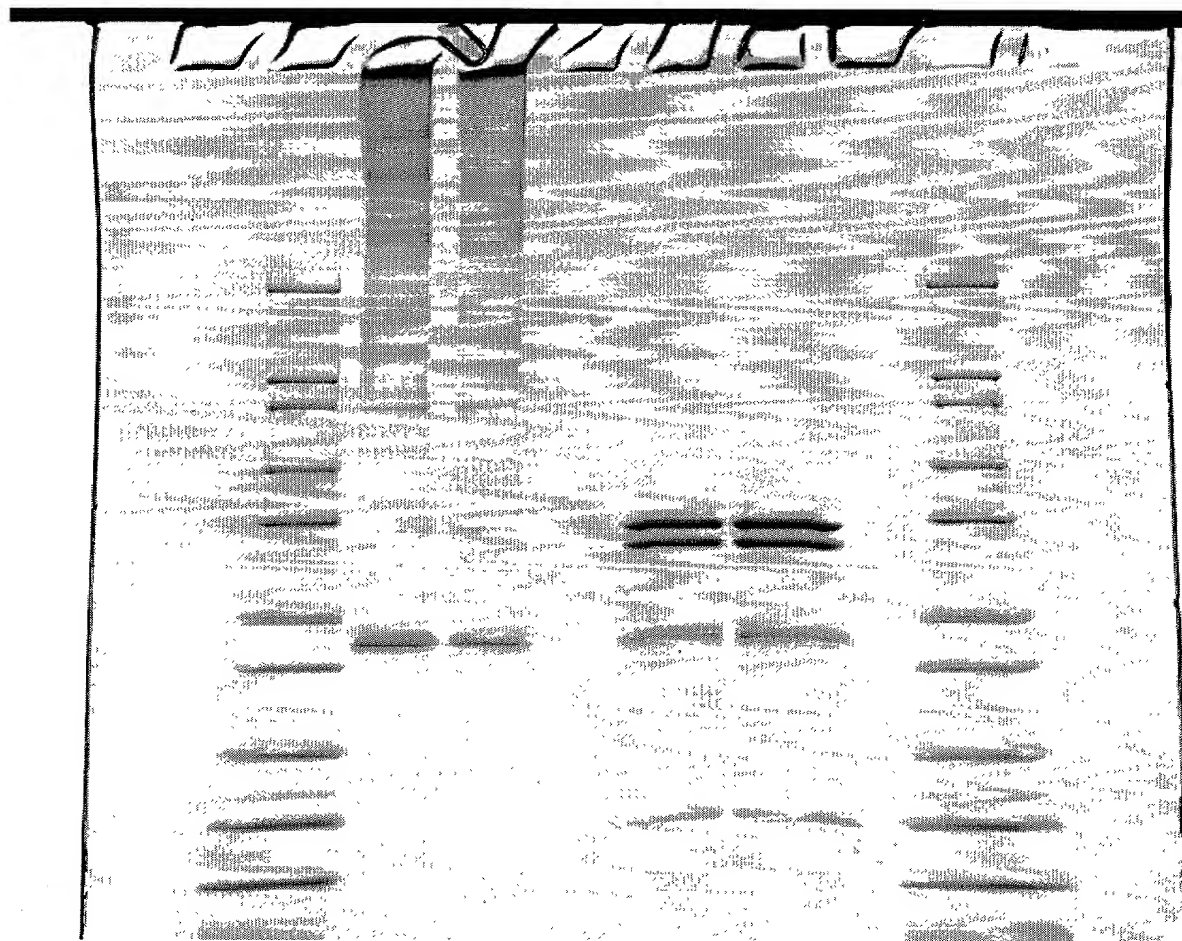
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8/14

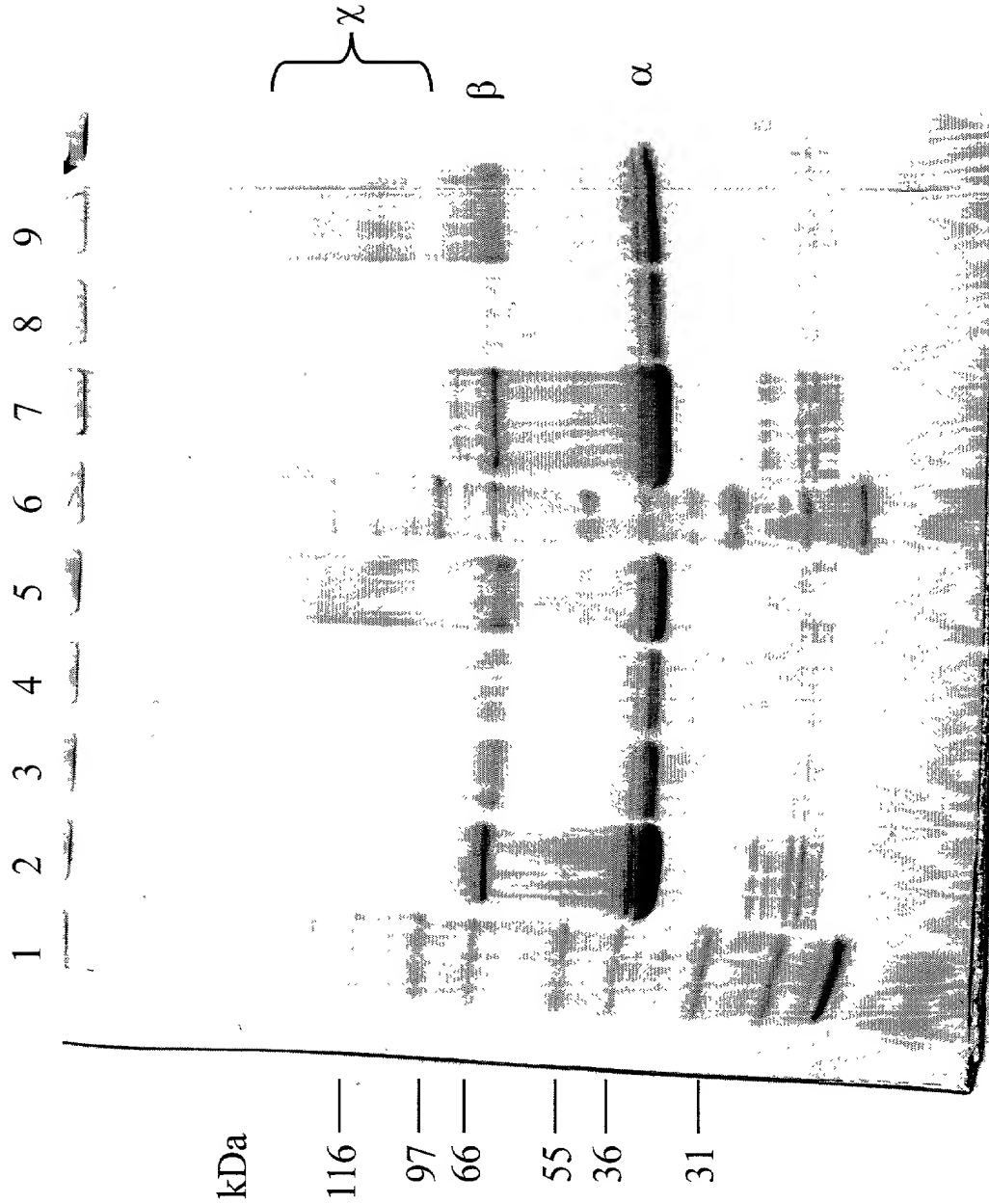
Fig. 8

1 2 3 4 5 6 7 8 9 10



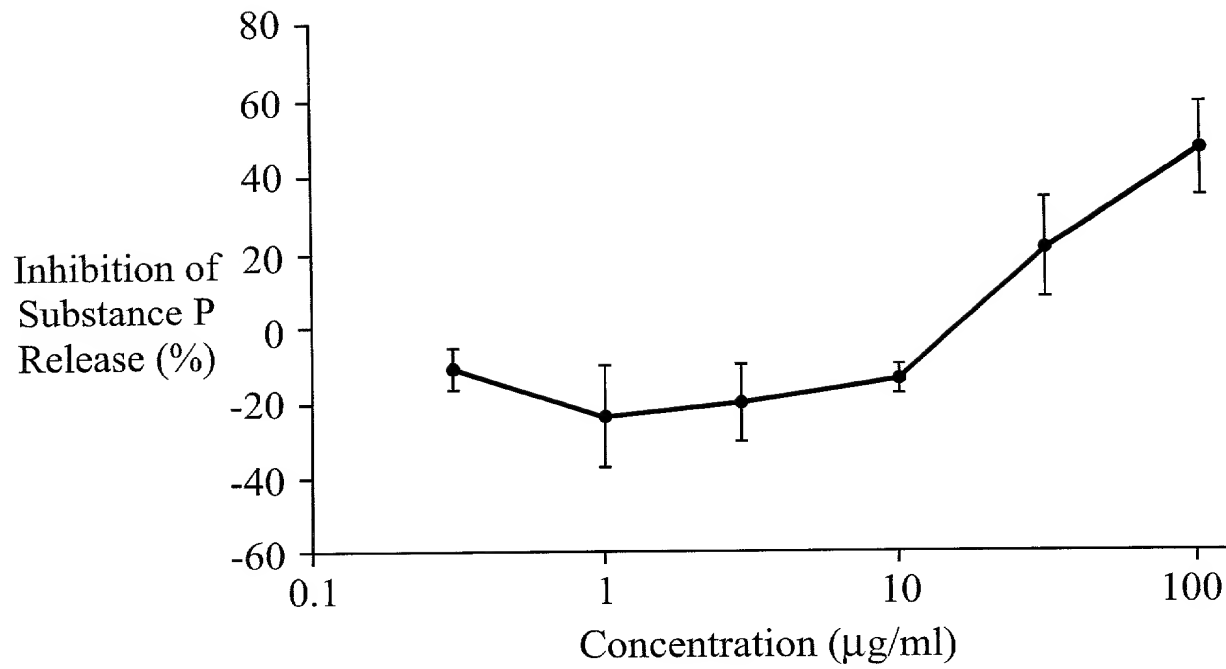
9/14

Fig. 9



10/14

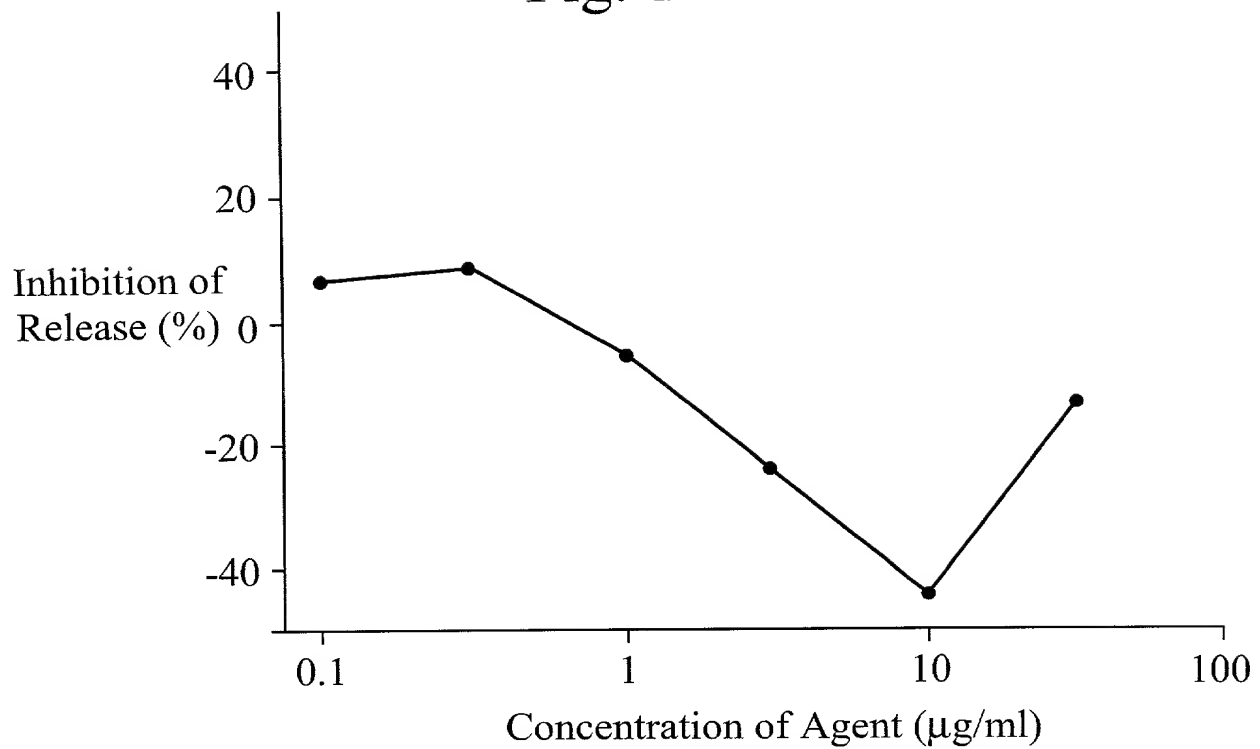
Fig. 10





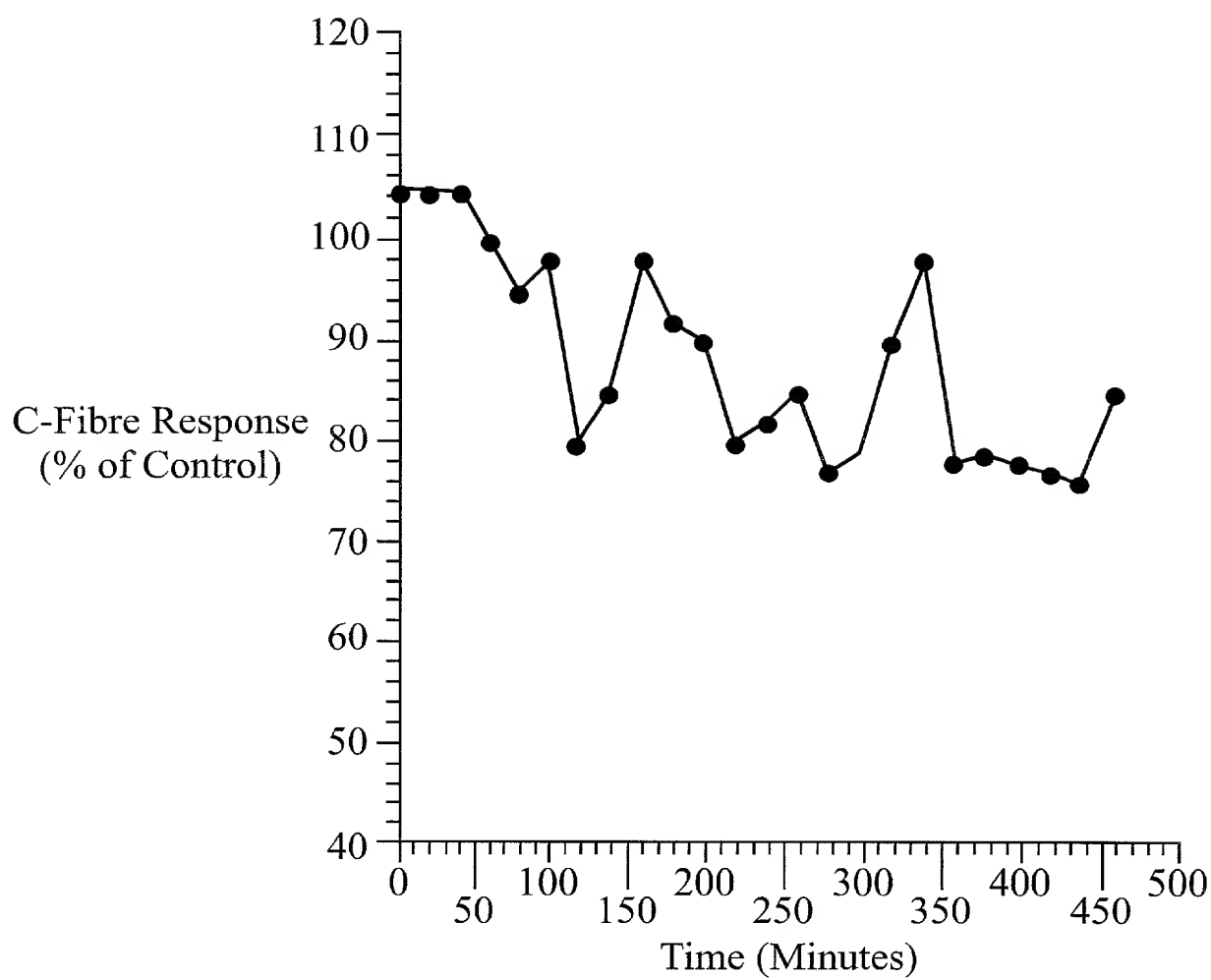
11/14

Fig. 11



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Fig. 12



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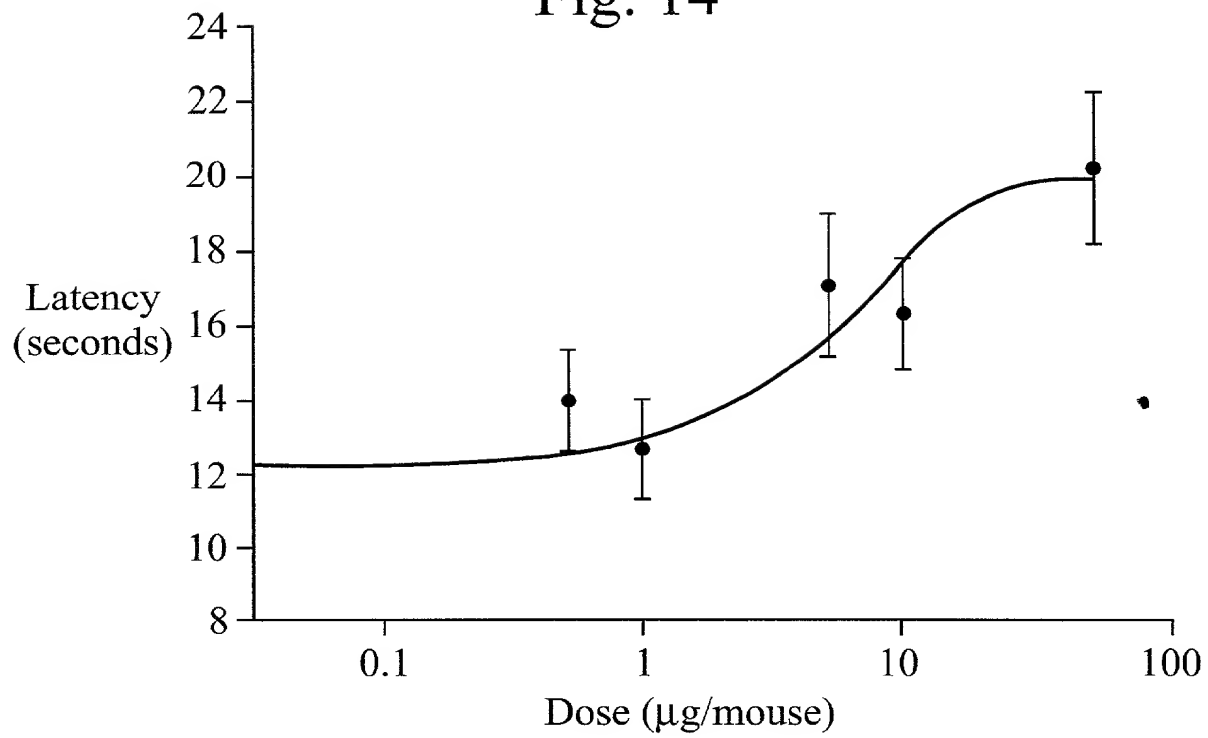
Fig. 13

Rat	Pretreatment (-4h)	Paw	µl Plasma /100mg tissue
1.	<i>Erythrina cristagalli</i> lectin	Stimulated	18.4
	None	Nonstimulated	4.7
2.	<i>Erythrina cristagalli</i> lectin	Stimulated	17.5
3.	Vehicle (Tyrode)	Stimulated	32.2
	None	Nonstimulated	4.3

Effect of *Erythrina cristagalli* lectin on neurogenic  
 inflammation induced by stimulation of the rat saphenous nerve.

14/14

Fig. 14



USE OF A LECTIN OR CONJUGATES FOR MODULATION OF C-FIBRE ACTIVITY

5 The present invention relates to the treatment of pain and to compounds that modulate C-fibre activity, in particular the use of these compounds for the treatment of diseases of which C-fibre activity is a component, such as pain, inflammation, psoriasis and other C-fibre related conditions, to methods and compositions therefor and manufacture of those compositions.

10 A number of disease conditions are known to be related to or associated with activity in C-fibre neurones, in particular pain, inflammation and psoriasis.

20 C-fibres are small diameter, unmyelinated neurones, which have their sensory termini and cell bodies in the peripheral nervous system (PNS), but which synapse in the dorsal horn of the spinal cord within the central nervous system (CNS). The accepted role of these afferent fibres is to signal strong, injury-threatening (noxious) stimuli or the presence of chemical irritants, including many inflammatory mediators to the CNS. The neurones are thus termed nociceptors. However, the importance of C-fibre neurons in a variety of other clinical conditions is only now emerging.

25 Uniquely amongst afferent neurones, many C-fibre nociceptors also have efferent, antidromic actions within the peripheral tissue that they innervate. When stimulated, the C-fibres release vasoactive mediators, which have potent actions on local blood vessels and on cells of the immune system. This invariably results in the phenomenon termed neurogenic inflammation. C-fibre efferent neurones store and co-release upon stimulation the neuropeptides substance P (SP) and calcitonin gene related peptide (CGRP). Both of these peptides are potently vasoactive and the blood vessel dilation by CGRP combined with an increase in SP induced vascular permeability results in  
30 plasma extravasation and peripheral oedema. This in turn recruits infiltration by eosinophils and other inflammatory cells and subsequently the full panoply of an inflammatory cascade.

- 2 -

Most citations report neurogenic inflammation in the skin. However, C-fibres are distributed widely throughout the body. In bronchial airway tissues, substances released from nociceptive terminals may cause smooth muscle contraction and also trigger the secretion of mucus. Detailed information is also available for C-fibre mediated effects in the bladder and the gastrointestinal tract. Neurogenic inflammation has now been clearly associated with a variety of disorders including asthma, ulcer formation and headache. It may also be a component of generalised inflammatory responses such as arthritis.

Psoriasis is a hyperproliferative epidermal disease whose aetiopathogenesis remains largely undefined. However, one of the most favoured hypotheses is that the condition correlates with an altered release of SP and CGRP neuropeptides by sensory efferent neurones.

Studies of neurogenic inflammation in psoriatic skin have demonstrated that morphological contact between mast cells and sensory C-fibres increases in developing (1-3 weeks) psoriatic lesions when compared to non-lesional controls. This increase reaches statistical significance in mature lesions. It is considered that the associated increase in neurogenic stimulation promotes mast cell degranulation and the release of inflammatory mediators. This in turn allows entry into the lesional dermis of various mediators that interact with keratinocytes to promote the hyperproliferation characteristic of psoriatic plaques.

A variety of psoriasis treatments are available ranging from moisturising creams, phototherapy and topical vitamin applications to corticosteroids and immune suppressants. However, none of these are universally effective nor do they appear to treat the underlying causes of the disease. Furthermore, the most effective treatments, especially for conditions requiring intensive therapy, have unpleasant and often toxic side effects.

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Pain can be classified in a number of ways depending upon the cause, the mechanism of action and the duration of suffering. Pain can also be categorised by the level of discomfort, *e.g.* mild, moderate or severe. Most pain is caused by direct mechanical, thermal or chemical damage to specific sensory receptors (nociceptors) which are located in the skin, muscle, some viscera and a number of other tissues. The perception of "feeling pain" follows the transduction and transmission of a noxious stimulus from the site of this insult or damage to the higher centres of the Central Nervous System (CNS).

Transduction of the majority of pain signals arises from the activation of small diameter, thinly myelinated or non-myelinated neurones known as A<sub>δ</sub>- and C-fibres respectively. These fibres have their cell bodies in the dorsal root ganglia, juxtaposed along the length of the spinal column. They synapse primarily in dorsal horn laminae I and II of the spinal cord. The most common nociceptors are innervated by C-fibres.

The transmission of a pain stimulus (nociception) is a complex process. There are many chemical transmitters involved at the site of insult and throughout the Peripheral Nervous System (PNS) and CNS. For each of these chemical transmitters there is also an associated receptor, or group of receptors, which transduce and transmit the pain impulse.

Receptors can be designated as either excitatory or inhibitory. Activation of excitatory receptors causes neuronal firing, resulting in either an increase in neurotransmitter release or an increase in the excitability of neurones. In contrast, activation of inhibitory receptors causes a decrease in neuronal firing, a reduction in transmitter release and may cause a reduction in neurone excitability.

The interaction of pain neurotransmitters with their receptors provides a large number of potential intervention points for novel therapies for the treatment

  
- 4 -

of pain. Each element, receptor, chemical mediator, neurotransmitter, ion channel and synapse, in this complex pathway is a potential target for blockade.

5 WO96/33273 describes toxin conjugates comprising a clostridial neurotoxin component and a Targeting Moiety selected to target peripheral sensory afferents. The clostridial neurotoxin component of the conjugate possess a protease activity specific for components of the neurosecretory machinery (see Claim 1). Amongst a large number of potential Targeting Moieties (see  
10 pages 24 and 25), lectins are listed (see line 12 on page 13).

EP-A-602686 describes the use of lectin concentrates obtained from mistletoe in raising the natural immune resistance in humans and mammals, and/or for  
15 tumour therapy. In more detail, the lectin concentrates contain a high proportion of immunologically active galactose-specific lectin designated ML1.

The current analgesic standards are the opiates, for example morphine. While these compounds are effective in a range of pain conditions, they do not provide a panacea. Their effects are short lived, thus requiring frequent  
20 application. Furthermore, there are associated unpleasant side effects of respiratory depression, nausea, dependency, addiction and induction of tolerance.

Activity of C-fibres is also implicated in the modulation of mucus release in  
25 disease conditions such as those involving mucus hypersecretion.

It is an object of the present invention to provide new methods and compositions for treatment of pain and for treatment of C-fibre related disease conditions such as inflammation, psoriasis, mucus hypersecretion and pain.  
30

Accordingly, a first aspect of the invention provides the use of a lectin in manufacture of a medicament for modulation of C-fibre neurone activity. The first aspect of the invention also provides a method of modulating C-fibre activity by administering an effective amount of lectin.  
35

In use of an embodiment of the invention, a lectin administered in a pharmaceutical composition binds to a C-fibre neurone and inhibits



4a

5 transmission of nerve cell impulses via that neurone, treating and thereby reducing a disease condition caused by or involving excessive activity of that C-fibre neurone.

Oligosaccharide carbohydrate receptors regulate key stages in many physiological processes of pharmaceutical importance such as inflammation, oncology, immunology, neural, infectious and other types of diseases

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(Edmonds, B. J. and Koenig, E. [1990] *Cell Motil. Cytoskeleton*, **17**, 106-17; Edmonds, B. J. and Koenig, E. [1991] *J. Neurocytol.* **20**, 232-47; Gupta, D., Arango, R. and others [1994] *Biochemistry*, **33**, 2503-08). Lectins are a class of proteins, often glycoproteins, that bind to carbohydrate structures and are known to agglutinate cells and/or precipitate complex carbohydrates. Two publications describing how lectins bind to neuronal cells are Silverman, J. D. and Kruger, L. (1990), selective neuronal glycoconjugate expression in sensory and autonomic ganglia: relation of lectin reactivity to peptide and enzyme markers, *J. Neurophysiol.* **19**, 789-801; and Streit, W.J., Schulte, B.A., Balentine, D. and Spicer, S.S. (1985), histochemical localization of galactose-containing glycoconjugates in sensory neurons and their processes in the Central and Peripheral Nervous System of the rat, *J. Histochem. Cytochem.* **33**, 1042-52. Lectins can be isolated from a wide range of natural sources including seeds, plant roots and bark, fungi, bacteria, seaweed and across the whole range of life forms from viruses to mammals. Some antibodies may mimic the *in vivo* activity of lectins. The most commonly exploited sources of lectins are the seeds of plants. The precise physiological role of lectins in nature is still unknown, but they have proved to be very valuable in a wide variety of applications *in vitro* including blood grouping and histochemical staining for cell surface markers. It is known in the literature that lectins have demonstrable selectivity for cells of different origin.

Due to the ubiquitous nature of oligosaccharide structures, lectins bind to a large number of cells. However, because of the known complexity and specificity of the transduction and transmission pathways of C-fibre neurones, it is particularly surprising and unexpected that lectins can bind to neurones so as to modulate C-fibre and/or A<sub>δ</sub>-fibre activity. For the purposes of this invention a "lectin" or a "lectin domain" is the whole of or that part of a peptide, protein or glycoprotein, or mimic thereof, that has the ability to bind specifically to mono- or oligosaccharide structures. The invention is of application without limit to particular sub-groups of lectins, though preferred lectins are those that bind galactosyl residues, for example terminal  $\beta$ -D-

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galactosyl or terminal  $\alpha$ -D-galactosyl residues or N-acetylgalactosamine residues, or glucosyl residues.

5 In use of an embodiment of the invention, a lectin binds to a surface structure or structures (the Binding Site [BS]) which is characteristic of, and has a degree of specificity for relevant sensory effector cells and/or neurones in the peripheral or central nervous system responsible for the afferent or projection transmission of pain or the regulation of said transmission. Next, it modulates the function of such cells so that either the transduction or transmission of  
10 the pain signal is reduced or abolished. Such modulation may be due to suppression of the activity of afferent and or projection neurones or due to promotion of the activity of inhibitory neurones.

15 One aspect of the invention thus advantageously provides a further class of analgesic compositions and uses of these compositions for treatment of pain. The invention provides use of a lectin in manufacture of a medicament for treatment of pain and a method of treatment of pain comprising administration of an effective amount of a lectin. In specific embodiments of the invention, lectins have been tested using the mouse hot plate model - an industry  
20 standard model acknowledged as predictive of human response - and found to be analgesic. The mouse hot-plate model is acknowledged as a model for human pain in Heilman, R. D. *et al.* (1976): An evaluation of the hot plate technique to study narcotic analgesics. *Res. Comm. Chem. Pathol. Pharmacol.* 13 (4), 635-647.

25 The lectin applications of the present invention have demonstrated equivalent latency, prolonged duration and equivalent potency when compared with the analgesic effects of morphine.

30 In a specific embodiment of the invention a galactoseries-specific lectin is extracted from the coral tree *Erythrina cristagalli* and administered intrathecally, exhibiting strong analgesic activity. In a further specific

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embodiment of the invention a galactoseries-specific lectin is extracted from the coral tree *Erythrina corallodendron* and administered intrathecally, also exhibiting strong pain-reducing activity. These illustrative lectins are heterodimeric and homodimeric glycoproteins respectively of approximate molecular weight of 60kDa (Arango, R. and others [1992] *Eur. J. Biochem.* 205, 575-81). In a still further specific embodiment of the invention, a glucosyl-specific lectin is analgesic in the mouse hot plate model.

A list of commercially available lectins appears in the 1998 Sigma catalogue.

A further example of a lectin, specifically a bacterial lectin is PA-I from *Pseudomonas aeruginosa*. This is a D-galactose binding lectin with a molecular weight of 13kDa (Garber, N., Guempel, U. and others (1992). *Biochim. Biophys. Acta.* 1116, 331-3).

In use of a further embodiment of the invention, a lectin binds to a C-fibre neurone that innervates a psoriatic lesion and inhibits release of inflammatory modulators, including substance P. A further aspect of the innovation thus advantageously provides a class of compositions for treatment of psoriasis.

In use of a still further embodiment of the invention, a lectin binds to a C-fibre neurone which modulates mucus release or control of mucus release. A still further aspect of the invention thus advantageously provides a class of composition and uses thereof for treatment of mucus hypersecretion.

Site and mode of delivery of lectin is typically a factor in obtaining the desired therapeutic effect. Thus, a topically and/or specifically delivered composition containing a lectin can comprise a lectin that binds to C-fibres but is not specific for C-fibres. By way of example, an embodiment of the invention provides for treatment of a localised disease condition such as psoriasis, using a lectin formulated in a cream which can be topically applied or a lectin formulated for sub-dermal injection. In this way, delivery of a lectin according to the invention is targeted and not systemic. In the case particularly of

formulations for injection, it is optional to include a further pharmaceutically active substance to assist retention at or reduce removal of the lectin from the site of administration, and one example is the use of a vasoconstrictor such as adrenaline. Such a formulation confers the advantage of increasing the residence time of lectin following administration and thus increasing and/or enhancing its effect.

Similar targeting delivery is appropriate for diseases involving C-fibre activity and for which the active lectin can be delivered via aerosol or other spray. An aerosol formulation of a lectin enables delivery to the lungs and/or other nasal and/or bronchial or airway passages, facilitating use of lectin for treatment of diseases such as mucus hypersecretion and rhinitis (hay fever).

Generally, the invention is of application to treatment of diseases caused by or exacerbated by antidromic activity in C-fibres, by inhibition of the antidromic activity, which is typically at least partially self-perpetuating or of an origin that is not clearly defined or presently understood. More specifically, the compounds and formulations of the invention can be used for treatment of inflammation including neurogenic inflammation, erythema, irritable bowel syndrome, headache, asthma, arthritis and as already mentioned pain including migraine.

Lectins and lectin domains may be arranged, covalently or non-covalently, so as to form oligomers and/or polymers, their functional units optionally separated using linkages which may include one or more spacer arms. The chemical conjugation and genetic fusion of such domains can be achieved by conventional methods. Lectins and lectin domains may be coupled to a distinct, additional, lectin or non-lectin companion protein forming a multi-component agent such that the efficacy of the agent is enhanced when compared to the native lectin component alone. Such an agent is optionally the expression product of a recombinant gene which provides for a minimal functional peptide domain such that the agent may be monomeric in form and

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may optionally be glycosylated. The agent may be the expression product of a recombinant gene delivered independently to the preferred site of action of the agent. Gene delivery technologies are widely reported in the literature (reviewed in "Advanced Drug Delivery Reviews" Vol. 27, [1997, Elsevier Science Ireland Ltd].

Methods for extracting and purifying lectins are known in the literature, for example, Iglesias, J. L., Lis, H. and Sharon, N. (1982) *Eur. J. Biochem.* 123, 247-252.

Gene expression technologies for the provision of functional, recombinant lectins, both glycosylated and non-glycosylated, are known in the literature (Arango, R. and others [1992] *Eur. J. Biochem.* 205, 575-81). By way of example, a cDNA encoding a lectin can be cloned into any of the pET series of plasmid vectors. Expression of the gene is thus under control of the T7 promoter and can be well regulated in the *E. coli* host. The expression product is recovered and purified from inclusion bodies using established techniques. These methods have been shown to produce non-glycosylated lectin proteins that otherwise retain all of the known functions of the native lectins.

Recombinant lectin protein fusions may be made by a variety of approaches. For example, the fusion of a gene coding for a lectin to a gene coding for a second lectin or non-lectin protein. These gene fusions may be separated by a further nucleic acid sequence coding for a flexible linker region (*e.g.* a polyglycine tract) which facilitates interaction of the fused proteins either with themselves (oligomerisation) or with other target molecules (receptors, other lectins etc.).

The lectin may further be expressed in single copy or multicopy arrangements on the surface of bacteriophage such that the monomers may associate to form a functional oligomeric molecule. In some instances, functionality may

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request the association of two or more separate bacteriophage displaying or require expressing lectin monomers. This approach may also be used for the expression of lectin fusion proteins.

5 The present invention further provides a composition comprising a lectin as described coupled to another peptide or protein. The peptide or protein may be a carrier or may impart a second function to the composition in addition to the C-fibre modulatory properties of the lectin. The peptide or protein may itself have a C-fibre and/or A<sub>δ</sub>-fibre modulatory property. The modulatory  
10 property of the peptide or protein may be independent from that of the lectin. Alternatively, the peptide or protein may modify the C-fibre and/or A<sub>δ</sub>-fibre modulatory property of the lectin.

The peptide or protein may be any molecule which is substantially free from Clostridial neurotoxin enzyme activity. Consistent with this definition, the  
15 peptide or protein may be, for example, a non-Clostridial toxin of plant or microbial origin, including but not limited to bacterial toxins. Further Examples of suitable peptides or proteins include inactive LH<sub>N</sub>/A (ie. inactive Clostridial neurotoxin), a second lectin (which may be the same as the first lectin or different), or multiple lectin conjugates (eg. dimers or trimers, etc).  
20

Thus, the lectin molecule of the present invention may be employed as a targeting moiety to direct the peptide or protein to relevant sensory effector cells and/or neurones in the PNS or CNS responsible for the afferent or  
25 projection transmission or pain or the regulation of said transmission. The peptide or protein may then exert a C-fibre and/or A<sub>δ</sub>-fibre modulation property at the target site.

The lectin of the present invention helps the *in vivo* stabilization of the peptide  
30 or protein.

In one embodiment, the present invention provides a composition comprising

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a first lectin conjugated to a second lectin, the lectins being optionally different or the same. All conjugate embodiments of the present invention may be coupled directly or via an intermediate linker. The lectins of the invention may also be modified to make derivatives, for example modified to  
5 remove a carbohydrate group whilst maintaining its ability to bind target cells.

In another embodiment, the peptide or protein is an endopeptidase, suitably of Clostridial origin. Specifically, the lectin of the invention can be coupled to an endopeptidase from a clostridial species, optionally from botulinum neurotoxin type A, or B. Such compositions are conveniently made by  
10 coupling a galactose-binding lectin to an enzymatically active fragment of a Clostridial neurotoxin, for example an LH<sub>N</sub> fragment of a botulinum neurotoxin, and in an illustrative example set out below a galactose-binding lectin from *Erythrina cristagalli* is coupled to an LH<sub>N</sub> fragment of botulinum neurotoxin type A. The present invention thus still further provides a method of preparing  
15 a composition of the invention by covalently attaching a lectin to another peptide or protein.

The lectin of the invention either in isolated form or incorporated into compounds or compositions may exert its activity by preventing the release of a neurotransmitter or neuromodulator from a primary sensory afferent, by  
20 inhibiting the release of a neurotransmitter or neuromodulator from a primary nociceptive afferent, by inhibiting the release of a neurotransmitter or neuromodulator from a projection neurone, by promoting the activity of an inhibitory neurone or by a combination thereof.  
25

The lectin of the invention may be optionally modified such that it possesses minimal or substantial no C-fibre and/or A $\delta$ -fibre modulation property. However, in this embodiment, the lectin either retains or possesses a  
30 targeting specificity to relevant sensory effector cells and/or neurones in the PNS or CNS which is preferably at least comparable with that of unmodified lectin. Thus, in this embodiment, the lectin simply targets the peptide or



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protein. Such modification may be achieved, for example, by random mutagenesis or site-directed mutagenesis of lectin- or conjugate-encoding nucleic acid or by direct chemical modification of the lectin or lectin conjugate.

5

In another aspect of the present invention, the peptide or protein is not coupled to the lectin. According to this embodiment, it is however preferred that the peptide or protein is associated with the lectin by, for example, a non-covalent linkage, an electrostatic interaction and/or Van der Waal's forces.

10

To this end, the lectin and/or the peptide or protein may be modified by introducing complementary surface charges which facilitate association of the two components *in vitro* and *in vivo*. Such modification may include introducing positively or negatively charged groups (eg. chemical groups or amino acid groups) into exposed surfaces on either or both of the two components.

15

Another aspect of the invention lies in a method of modulating C-fibre activity comprising administering an effective amount of a lectin to a patient. The lectin can be used to inhibit C-fibre activity, or to stimulate C-fibre activity.

20

Further aspects of the invention lie in a composition for modulation of C-fibre activity comprising a nucleic acid encoding a lectin, a method of modulating C-fibre activity comprising administering an effective amount of such a composition, and use of such a composition in manufacture of a medicament for modulation of C-fibre activity.

25

In a yet further aspect, the invention provides a pharmaceutical composition for modulation of C-fibre neurone activity, comprising

30

a lectin or a composition according to any of the above aspects of the invention; and

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at least one of a pharmaceutically acceptable carrier, excipient, adjuvant, propellant and or salt.

5 The compound may thus be formulated for oral, parenteral, continuous infusion, inhalation or topical application and encompasses delivery of the lectin or conjugate its nucleic acid coding sequence or its agonists. Intraspinal injection is another route of administration, though the present invention encompasses also any administration that delivers the compound to an appropriate or optimal site of intervention. Administration might take  
10 advantage of a variety of delivery technologies including microparticle encapsulation, viral delivery systems or high pressure aerosol impingement, including delivering a lectin-coding nucleic acid to a cell population in which it would be expressed and the gene product would be capable of effecting analgesia. Additionally, the target cells for lectin activity need not be the cells  
15 in which the gene is expressed.

Agents of the invention for treatment of pain may be administered to a patient by intrathecal or epidural injection in the spinal column at the level of the spinal segment involved in the innervation of an affected organ. This is, for  
20 example, applicable in the treatment of deep tissue pain, such as chronic malignant pain. The dosage ranges for administration of the compounds of the present invention are those to produce the desired therapeutic effect. It will be appreciated that the dosage range required depends on the precise nature of the lectin or composition, the route of administration, the nature of the formulation, the age of the patient, the nature, extent or severity of the  
25 patient's condition, contraindications, if any, and the judgement of the attending physician. Wide variations in the required dosage, however, are to be expected depending on the precise nature of the agent. Variations in these dosage levels can be adjusted using standard empirical routines for  
30 optimisation.

Fluid dosage forms are typically prepared utilising the compound and a

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pyrogen-free sterile vehicle. The compound, depending on the vehicle and concentration used, can be either dissolved or suspended in the vehicle. In preparing solutions the compound can be dissolved in the vehicle, the solution being made isotonic if necessary by addition of sodium chloride and sterilised by filtration through a sterile filter using aseptic techniques before filling into suitable sterile vials or ampoules and sealing. Alternatively, if solution stability is adequate, the solution in its sealed containers may be sterilised by autoclaving. Advantageously additives such as buffering, solubilising, stabilising, preservative or bactericidal, suspending or emulsifying agents and or local anaesthetic agents may be dissolved in the vehicle.

Dry powders, which are dissolved or suspended in a suitable vehicle prior to use, may be prepared by filling pre-sterilised drug substances and other ingredients into a sterile container using aseptic technique in a sterile area. Alternatively the drug and other ingredients may be dissolved into suitable containers using aseptic technique in a sterile area. The product is then freeze dried and the containers are sealed aseptically.

Compositions suitable for administration via spinal injection may be made up in a conventional manner and employed in conjunction with conventional administration devices.

Compositions of the previously filed International patent application PCT/GB98/03001 that contain lectins may be used in the present invention but are excluded from the scope of compositions claimed herein.

There now follows description of specific embodiments of the invention, illustrated by drawings in which:-

Fig. 1 shows a denaturing polyacrylamide gel analysis of ECL lectin, LH<sub>N</sub>/A companion protein and the subsequent chemical conjugates;

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Fig. 2 shows the analgesic effect of *Erythrina cristagalli* lectin in mice in a hot-plate model;

Fig. 3 shows the analgesic effect of lectin-conjugates is comparable to a supramaximal dose of morphine in mice in a hot-plate model;

Fig. 4 shows WGA lectin is analgesic in the mouse hot plate model;

Fig. 5 shows that *Bandeirea simplicifolia* lectin IB<sub>4</sub> is analgesic in the mouse hot plate model;

Fig. 6 illustrates SDS-PAGE analysis of a conjugate of wheat-germ agglutinin lectin and a companion protein (WGA-LH<sub>N</sub>/A);

Fig. 7 illustrates non-reducing SDS-PAGE analysis of a purified conjugate of *Erythrina corallodendron* lectin and a companion protein (ECoRL-LH<sub>N</sub>/A);

Fig. 8 illustrates SDS-PAGE analysis of a purified conjugate of *Bandeiraea simplicifolia* and a companion protein (IB<sub>4</sub>-LH<sub>N</sub>/A);

Fig. 9 illustrates SDS-PAGE analysis of conjugated oligomeric *Erythrina cristagalli* lectin (ECL);

Fig. 10 illustrates modulation of substance P release by *Erythrina cristagalli* lectin;

Fig. 11 illustrates modulation of substance P release by *Erythrina cristagalli* lectin conjugated to another protein (LH<sub>N</sub>/A(-));

Fig. 12 illustrates inhibition of C-fibre response to stimulation by *Erythrina cristagalli* lectin;

Fig. 13 illustrates antidromic effects of the *Erythrina cristagalli* lectin.

Fig. 14 Inhibition of response to painful thermal stimuli following application of *Erythrina cristagalli* to the mouse spinal cord *in vivo*.

5

Some of the above Figures are now described in more detail below:-

10

In Fig. 2, lectin was applied intrathecally (30 $\mu$ g in a 5 $\mu$ l vehicle volume). Onset of lectin-induced analgesia reaches a plateau at 1 hour post application and remains constant for at least 5 hours. Morphine achieves a maximal effect at 1 hour and then returns to control levels over a period of 5 hours. (Data is the mean of replicate readings from groups of 10 mice  $\pm$  SE).

15  
20

In Fig. 3, lectin-conjugate was applied intrathecally (30 $\mu$ g in a 5 $\mu$ l vehicle volume). Onset of lectin-conjugate induced analgesia reaches a plateau at 1 hour post application and remains constant for at least 5 hours. Lectin-conjugate analgesia is similar to a supramaximal dose (20X EC<sub>50</sub>) of morphine in this test, but is of much longer duration; morphine achieves a maximal effect at 1 hour and then returns to control levels over a period of 5 hours. (Data is the mean of replicate readings from groups of 10 mice  $\pm$  SE).

25

In Fig. 6, protein fractions were subjected to 4-20% polyacrylamide SDS-PAGE prior to staining with Coomassie blue. Lanes 6-8 were run in the presence of 0.1M DTT. Lanes 1 (&7) and 2 (& 8) represent derivatised WGA and derivatised LH<sub>N</sub>/A respectively. Lanes 3-5 represent conjugation mixture, post-Superose-12 chromatography and post GlcNAc-affinity chromatography respectively. Lanes 6 represents a sample of reduced final material. Approximate molecular masses (kDa) are indicated on the Figure.

30

In Fig. 7: Lane 1 = molecular weight markers; Lane 2 = post-affinity purified sample; and Lane 3 = pre-affinity purified sample.

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In Fig. 8: Lanes 2 & 9 = molecular markers (Novex, Mark 12); Lanes 3 & 4 = IB<sub>4</sub>-LH<sub>N</sub>/A; and Lanes 6 & 7 = IB<sub>4</sub>-LH<sub>N</sub>/A reduced by addition of 0.1M DTT.

5 In Fig. 9:  $\alpha$  represents lectin monomers;  $\beta$  represents lectin dimers;  $\chi$  represents lectin oligomers; Lane 1 = Mark 12 molecular markers; Lane 2 = ECL; Lane 3 = ECL derivatised with SMPB; Lane 4 = ECL derivatised with SPDP; Lane 5 = non-reduced oligomeric ECL-ECL mix; Lane 6 = Mark 12 molecular markers; Lane 7 = Reduced SMPB-derivatised ECL; Lane 8 = Reduced SPDP-derivatised ECL; and Lane 9 = Reduced ECL-ECL conjugate mix.

10 In Fig. 10, data are presented as the mean of at least three determinations  $\pm$  SEM.

15 In Fig. 11, conjugate was applied to eDRG neurons for three days prior to determination of the release of substance P. Released substance P was related to controls to determine % release;

20 The invention thus provides lectins and lectin derivatives useful *inter alia* for the treatment of pain and components for synthesis of molecules as described in WO94/21300, WO96/33273, and WO99/17806.

**Example 1.****Preparation of *Erythrina cristagalli* lectin.**

- 5 Lectins from *E. cristagalli* may be prepared as described by Iglesias, J. L., Lis, H. and Sharon, N. (1982) *Eur. J. Biochem.* **123**, 247-252. Alternatively the purified lectin may be purchased from a range of suppliers such as Sigma.

**Example 2.****Method for the preparation of oligomers of *Erythrina cristagalli* lectin.****Materials**

10 *E. cristagalli* lectin (ECL) was obtained from Sigma Ltd. SPDP was from Pierce Chemical Co. PD-10 desalting columns were from Pharmacia. Dimethylsulphoxide (DMSO) was kept anhydrous by storage over a molecular sieve. Denaturing sodium dodecylsulphate polyacrylamide gel electrophoresis (SDS-PAGE) was performed using gels and reagents from Novex. Immobilised lactose-agarose was obtained from Sigma Ltd. Additional reagents were  
20 obtained from Sigma Ltd.

**Method**

25 The lyophilised lectin was rehydrated in phosphate buffered saline (PBS; 10mM Na<sub>2</sub>HPO<sub>4</sub>, 140mM NaCl, 2.7mM KCl, 1.8mM KH<sub>2</sub>PO<sub>4</sub>, pH7.3) to a final concentration of 10 mg/ml. Aliquots of this solution were stored at -20°C until used.

30 For conjugation the lectin was reacted with an equal concentration of SPDP by the addition of a 10mM stock solution of SPDP in DMSO with mixing. After one hour at room temperature the reaction was terminated by desalting into PBS over a PD-10 column.

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From one aliquot of the SPDP derivatised lectin material the thiopyridone leaving group was removed by reduction with dithiothreitol (DTT, 5mM, 30 min). The product of this reaction was analysed spectrophotometrically at 280 nm and 343 nm to determine the degree of derivatisation achieved. The degree of derivatisation achieved was  $0.8 \pm 0.06$  mol/mol. The thiopyridone and DTT were removed by once again desalting into PBS over a PD-10 column.

A second aliquot of SPDP derivatised lectin material protein was desalted into PBSE (PBS containing 1mM EDTA).

The bulk of the derivatised ECL lectin and the DTT treated derivatised ECL were mixed in proportions such that the DTT treated derivatised ECL was in greater than three-fold molar excess. The oligomerisation reaction was allowed to proceed for  $> 16$  h at  $4^{\circ}\text{C}$ .

The product mixture was centrifuged to clear any precipitate that had developed. The supernatant was concentrated by centrifugation through concentrators (with 10000-50000 molecular weight exclusion limit), dialysed against PBS, and stored at  $4^{\circ}\text{C}$  until use.

The oligomerisation products were analysed by SDS-PAGE on 4-20% polyacrylamide gradient gels, followed by staining with Coomassie Blue.

### Example 3.

Method for the preparation of a conjugate between *Erythrina cristagalli* lectin and a companion protein.

#### Materials

*E. cristagalli* lectin (ECL) was obtained from Sigma Ltd. The companion protein in this example is a clostridial enzyme designated LH<sub>N</sub>/A and was prepared



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essentially by the method of Shone C.C., Hambleton, P., and Melling, J. 1987, *Eur. J. Biochem.* **167**, 175-180. SPDP was from Pierce Chemical Co. PD-10 desalting columns were from Pharmacia. Dimethylsulphoxide (DMSO) was kept anhydrous by storage over a molecular sieve. Denaturing sodium dodecylsulphate polyacrylamide gel electrophoresis (SDS-PAGE) was performed using gels and reagents from Novex. Immobilised lactose-agarose was obtained from Sigma Ltd. Additional reagents were obtained from Sigma Ltd.

### Method

The lyophilised lectin was rehydrated in phosphate buffered saline (PBS; 10mM Na<sub>2</sub>HPO<sub>4</sub>, 140mM NaCl, 2.7mM KCl, 1.8mM KH<sub>2</sub>PO<sub>4</sub>, pH7.3) to a final concentration of 10 mg/ml. Aliquots of this solution were stored at -20°C until used.

The lectin was reacted with an equal concentration of SPDP by the addition of a 10mM stock solution of SPDP in DMSO with mixing. After one hour at room temperature the reaction was terminated by desalting into PBS over a PD-10 column.

The thiopyridone leaving group was removed from the product by reduction with dithiothreitol (DTT, 5mM, 30 min). The product of this reaction was analysed spectrophotometrically at 280 nm and 343 nm to determine the degree of derivatisation achieved. The degree of derivatisation achieved was 0.8±0.06 mol/mol. The thiopyridone and DTT were removed by once again desalting into PBS over a PD-10 column.

The companion protein was desalted into PBSE (PBS containing 1mM EDTA). The resulting solution (0.5-1.0 mg/ml) was reacted with a four- or five-fold molar excess of SPDP by addition of a 10mM stock solution of SPDP in DMSO. After 3 h at room temperature the reaction was terminated by desalting over a PD-10 column into PBS.

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A portion of the derivatised companion protein was removed from the solution and reduced with DTT (5mM, 30 min). This sample was analysed spectrophotometrically at 280 nm and 343 nm to determine the degree of derivatisation. The degree of derivatisation achieved was  $2.26 \pm 0.10$  mol/mol. The bulk of the derivatised companion protein and the derivatised ECL were mixed in proportions such that the ECL was in greater than three-fold molar excess. The conjugation reaction was allowed to proceed for > 16 h at 4°C.

The product mixture was centrifuged to clear any precipitate that had developed. The supernatant was concentrated by centrifugation through concentrators (with 10000-50000 molecular weight exclusion limit) prior to a two step purification strategy. As the first step, the concentrated material was applied to a Superose 12 column on an FPLC chromatography system (Pharmacia). The column was eluted with PBS and the elution profile followed at 280 nm.

Fractions were analysed by SDS-PAGE on 4-20% polyacrylamide gradient gels, followed by staining with Coomassie Blue. The major band of conjugate has an apparent molecular mass of between 130-160kDa; this is separated from the bulk of the remaining unconjugated companion protein and more completely from the unconjugated ECL. Fractions containing conjugate were pooled prior to the second chromatography step; immobilised lactose-agarose. Selected post-Superose-12 fractions were applied to PBS-washed lactose-agarose and incubated for 2 hours at 4°C to facilitate binding. Lectin-containing protein conjugates remained bound to the agarose during subsequent washing with PBS to remove contaminants. Lectin conjugate was eluted from the column by the addition of 0.3M lactose (in PBS) and the elution profile followed at 280 nm. The fractions containing conjugate were pooled, dialysed against PBS, and stored at 4°C until use. Figure 1 shows a typical SDS-PAGE profile of ECL lectin, companion LH<sub>N</sub>/A and the conjugation products at different stages during purification.

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**Example 4.**

The production of a conjugate between a lectin from *Erythrina corallodendron* and a companion protein.

5

The procedure for production of a conjugate between a lectin from *Erythrina corallodendron* and LH<sub>N</sub>/A is essentially as described in Example 3 but with the following differences:

10

**Materials**

Lectin from *E. corallodendron* (ECorL) was obtained from Sigma Ltd.

**Example 5.**

15

**In vivo analgesic effects of *Erythrina cristagalli* lectin**

20

**Animals**

Adult outbred mice (MF1) of either sex, weight range 20 to 30g have been used for these studies. All animals are acclimatised for a minimum of 4 days by maintaining them in the room in which the tests are to be carried out. Pre-injection data is acquired from all animals on the day before test substances are introduced and this serves as baseline data for individual animals. In addition, this pre-test data allows screening of animals exhibiting extreme responses to the various stimuli. Experiments are done on groups of 10 animals with replicate readings taken at each test point.

25

**Intrathecal administration.**

30

Mice are anaesthetized by induction with 4% fluothane carried in a 50:50 mixture of oxygen and nitrous oxide with a flow rate of 400-500cc per minute. Once anaesthesia is induced the percentage is reduced to 1.5 to 2% for maintenance.

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The pelvis of the mouse is located, the fur is clipped around the appropriate area and a small incision (about 5mm) is made in the skin above the spinal column.

5 Using a 30 gauge disposable needle attached to a 50 $\mu$ l Hamilton syringe with luer fitting the lectin material is injected into the intrathecal space. The site of injection is normally chosen to be between lumbar vertebrae 5 and 6. Holding the syringe at an angle of about 20° above the vertebral column the needle is inserted into the tissue to one side of the vertebrae so that it slips  
10 into the groove between the spinous and transverse processes. The needle is then moved carefully forward to the intervertebral space whilst decreasing the angle of the syringe to about 10°. Once inserted into the appropriate spot a characteristic flick of the tail is often, but not invariably, observed. 5 $\mu$ l of test material is then injected into the intrathecal space and the needle  
15 withdrawn. The skin incision is then closed with a single wound clip and the animal placed in a box to allow recovery. Mice have been observed to recover rapidly from this procedure and become fully mobile within two minutes.

20 *E. cristagalli* lectin agents were applied intrathecally at 30 $\mu$ g in a 5 $\mu$ l volume of physiological saline vehicle. The data in Figure 2 shows a rapid onset of lectin induced analgesia which approaches a maximum within 1 hour of application and remains constant for at least 5 hours. Lectin induced analgesia is similar to that of a 10 $\mu$ g/mouse supramaximal (20 times the mouse EC50)  
25 of morphine in this test but is of much longer duration; morphine achieves a maximal effect at 1 hour and then declines over a period of 5 hours.

#### Example 6.

30 *In vivo* analgesic effects of *Erythrina cristagalli* lectin conjugates.

#### Animals

- 24 -

Adult outbred mice (MF1) of either sex, weight range 20 to 30g have been used for these studies. All animals are acclimatised for a minimum of 4 days by maintaining them in the room in which the tests are to be carried out. Pre-injection data is acquired from all animals on the day before test substances are introduced and this serves as baseline data for individual animals. In addition, this pre-test data allows screening of animals exhibiting extreme responses to the various stimuli. Experiments are done on groups of 10 animals with replicate readings taken at each test point.

#### *Intrathecal administration.*

Mice are anaesthetized by induction with 4% fluothane carried in a 50:50 mixture of oxygen and nitrous oxide with a flow rate of 400-500cc per minute. Once anaesthesia is induced the percentage is reduced to 1.5 to 2% for maintenance.

The pelvis of the mouse is located, the fur is clipped around the appropriate area and a small incision (about 5mm) is made in the skin above the spinal column.

Using a 30 gauge disposable needle attached to a 50 $\mu$ l Hamilton syringe with luer fitting the lectin material is injected into the intrathecal space. The site of injection is normally chosen to be between lumbar vertebrae 5 and 6. Holding the syringe at an angle of about 20° above the vertebral column the needle is inserted into the tissue to one side of the vertebrae so that it slips into the groove between the spinous and transverse processes. The needle is then moved carefully forward to the intervertebral space whilst decreasing the angle of the syringe to about 10°. Once inserted into the appropriate spot a characteristic flick of the tail is often, but not invariably, observed. 5 $\mu$ l of test material is then injected into the intrathecal space and the needle withdrawn. The skin incision is then closed with a single wound clip and the animal placed in a box to allow recovery. Mice have been observed to recover rapidly from this procedure and become fully mobile within two

- 25 -

minutes.

5 *E. cristagalli* lectin-LH<sub>N</sub>/A conjugates were applied intrathecally at 30 $\mu$ g in a 5 $\mu$ l volume of physiological saline vehicle. The data in Figure 3 shows a rapid onset of lectin-conjugate induced analgesia which approaches a maximum within 1 hour of application and remains constant for at least 5 hours. Lectin-conjugate analgesia is similar in intensity to that of a 10 $\mu$ g/mouse supramaximal (20 times the mouse EC50) of morphine in this test but is of much longer duration; morphine achieves a maximal effect at 1 hour and then declines over a period of 5 hours.

#### Example 7.

*In vivo* analgesic effects of a glucosyl-reactive lectin from *Triticum vulgaris*.

##### Materials

*Triticum vulgaris* wheat germ agglutinin lectin (WGA) was obtained from Sigma Ltd.

##### Method

Intrathecal administration of *Triticum vulgaris* lectin WGA was as described for Examples 5 and 6.

25 The data in Figure 4 shows that by 24-30 hours post application the hot-plate paw withdrawal time in WGA treated mice is much greater than that of PBS treated control groups. By 48 hours post application the analgesic effect from the single dose has dissipated.

#### Example 8.

30 *In vivo* analgesic effects of a galactosyl-reactive lectin IB<sub>4</sub> from *Bandeiraea simplicifolia*.

### Materials

*Bandeiraea simplicifolia* lectin IB<sub>4</sub> was obtained from Sigma Ltd.

### Method

- 5 Intrathecal administration of *Bandeiraea simplicifolia* lectin IB<sub>4</sub> was as described for Examples 5 and 6.

10 The data in Figure 5 shows the analgesic effect of a single intrathecal dose of lectin IB<sub>4</sub> reagent in a mouse hot plate model over a 10 hour period. A significant increase in withdrawal latency is observed at 1 hour post application with an apparent maximal activity at 4 hours. Analgesia was still clearly discernible over control-group animals at 10 hours post application.

### Example 9.

The production of a conjugate between *Triticum vulgaris* lectin and a companion protein.

### Materials

20 Lectin from *Triticum vulgaris* (WGA) was obtained from Sigma Ltd.

LH<sub>N</sub>/A was prepared essentially by the method of Shone C.C., Hambleton, P., and Melling, J. 1987, *Eur. J. Biochem.* 167, 175-180.

SPDP was from Pierce Chemical Co.

PD-10 desalting columns were from Pharmacia.

25 Dimethylsulphoxide (DMSO) was kept anhydrous by storage over a molecular sieve.

Denaturing sodium dodecylsulphate polyacrylamide gel electrophoresis (SDS-PAGE) and non-denaturing polyacrylamide gel electrophoresis was performed  
30 using gels and reagents from Novex.

Additional reagents were obtained from Sigma Ltd.

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*Method*

The lyophilised WGA lectin was rehydrated in phosphate buffered saline (PBS) to a final concentration of 10 mg/ml. Aliquots of this solution were stored at -20°C until use.

5

The WGA was reacted with an equal concentration of SPDP by the addition of a 10mM stock solution of SPDP in DMSO with mixing. After one hour at room temperature the reaction was terminated by desalting into PBS over a PD-10 column.

10

The thiopyridone leaving group was removed from the product to release a free -SH group by reduction with dithiothreitol (DTT; 5mM; 30 min). The thiopyridone and DTT were removed by once again desalting into PBS over a PD-10 column.

15

The companion protein, LH<sub>N</sub>/A, was desalted into PBSE (PBS containing 1mM EDTA). The resulting solution (0.5-1.0 mg/ml) was reacted with a four-fold molar excess of SPDP by addition of a 10mM stock solution of SPDP in DMSO. After 3 h at room temperature the reaction was terminated by desalting over a PD-10 column into PBSE.

20

A portion of the derivatized LH<sub>N</sub>/A was removed from the solution and reduced with DTT (5mM, 30 min). This sample was analysed spectrophotometrically at 280nm and 343nm to determine the degree of derivatisation. The degree of derivatisation achieved was  $3.53 \pm 0.59$  mol/mol.

25

The bulk of the derivatized LH<sub>N</sub>/A and the derivatized WGA were mixed in proportions such that the ExL was in greater than three-fold molar excess. The conjugation reaction was allowed to proceed for >16 h at 4°C.

30

The product mixture was centrifuged to clear any precipitate that had developed. The supernatant was concentrated by centrifugation through



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concentrators (with 10000 molecular weight exclusion limit) before application to a Superose 12 column on an FPLC chromatography system (Pharmacia). The column was eluted with PBS and the elution profile followed at 280 nm.

5

Fractions were analysed by SDS-PAGE on 4-20% polyacrylamide gradient gels, followed by staining with Coomassie Blue (Figure 6). The major conjugate products have an apparent molecular mass of between 106-150kDa, these are separated from the bulk of the remaining unconjugated LH<sub>N</sub>/A and more completely from the unconjugated WGA.

10

Fractions containing conjugate were pooled prior to addition to PBS-washed N-acetylglucosamine-agarose. Lectin-containing proteins (ie. WGA-LH<sub>N</sub>/A conjugate) remained bound to the agarose during washing with PBS to remove contaminants (predominantly unconjugated LH<sub>N</sub>/A). WGA-LH<sub>N</sub>/A conjugate was eluted from the column by the addition of 0.3M N-acetylglucosamine (in PBS) and the elution profile followed at 280 nm.

15

The fractions containing conjugate were pooled, dialysed against PBS, and stored at 4°C until use.

20

On the gel there are bands due to lectin alone in fractions containing the conjugate, this material is probably due to the non-covalent homo-dimeric nature of the WGA; where only one monomer of WGA is covalently attached to the LH<sub>N</sub>/A the other is dissociated from the complex by the SDS in the electrophoretic procedure giving rise to these bands.

25

#### Example 10.

The production of a conjugate between *Erythrina corallodendron* lectin and a companion protein.

30

### Materials

*Erythrina corallodendron* lectin was obtained from Sigma.

### Method

5 The methodology for production of *Erythrina corallodendron* lectin conjugated to a companion protein is similar to that described in Example 9 for the production of WGA-LH<sub>N</sub>/A. See Figure 7 for SDS-PAGE analysis of conjugated protein.

### 10 Example 11.

The production of a conjugate between *Bandeiraea simplicifolia* lectin and a companion protein.

### 15 Materials

*Bandeiraea simplicifolia* lectin was obtained from Sigma.

### Method

20 The methodology for production of *Bandeiraea simplicifolia* lectin conjugated to a companion protein is similar to that described in Example 9 for the production of WGA-LH<sub>N</sub>/A. See Figure 8 for SDS-PAGE analysis of conjugated protein.

### 25 Example 12.

Preparation of oligomeric *Erythrina cristagalli* lectin.

### Materials

*Erythrina cristagalli* lectin was obtained from Sigma.

30

SPDP & SMPB were obtained from Pierce.

### Method

The lyophilised lectin was rehydrated in phosphate buffered saline (PBS) to a final concentration of 2 mg/ml.

- 5 An aliquot of ECL was reacted with a 1.5 times molar excess of SPDP by the addition of a 10mM stock solution of SPDP in DMSO. After rotating for 90 minutes at room temperature, the reaction was terminated by desalting into PBS over a PD-10 column.

10 The thiopyridone leaving group was removed from the product to release a free -SH group by reduction with dithiothreitol (DTT; 5mM; 30 min). The thiopyridone and DTT were removed by once again desalting into PBS over a PD-10 column.

15 A second aliquot of ECL was reacted with a 2.5 times molar excess of SMPB (a non-reducible linker) by the addition of a 10mM stock solution of SMPB in DMSO. After rotating for 90 minutes at room temperature, the reaction was terminated by desalting into PBS over a PD-10 column.

- 20 The derivatised ECL samples were mixed together and the conjugation reaction was allowed to proceed by rotation at 4°C for > 16 h.

Aliquots of the derivatised lectins and the product mixture were analysed by SDS-PAGE on 4-20% polyacrylamide gradient gels, followed by staining with  
25 Coomassie Blue (see Figure 9).

### Example 13.

Preparation of recombinant *Erythrina cristagalli* lectin.

### Materials

30 Viable *Erythrina cristagalli* seeds were obtained from a local horticultural

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distributor.

### Method

5 A number of methods for obtaining the coding sequence for *Erythrina cristagalli* lectin (ECL) were employed. In the first instance, methodology similar to that described by Arango *et al* for *Erythrina corallodendron* [Arango, R., Rozenblatt, S, & Sharon, N. (1990), FEBS Lett. 264, 109-111] was used to isolate the coding sequence from messenger RNA.

10 Alternatively, the coding sequence for *Erythrina cristagalli* was obtained by specific amplification from genomic DNA. Briefly, genomic DNA was extracted from *Erythrina cristagalli* using commercially sourced DNA extraction kits. The sequence of the N-terminal amino acids of ECL was determined in order to facilitate primer design. Using degenerate primers designed to have  
15 homology with the N-terminus of ECL and the published sequence of *Erythrina corallodendron*, amplification of coding region was facilitated.

20 Specific amplification product was isolated, cloned into a suitable vector and sequenced. Sequence data confirmed the presence of codons suitable for the expression of polypeptide that had homology to the lectin isolated from *Erythrina corallodendron*.

25 ECL coding region was cloned into a suitable expression vector and expression of recombinant ECL induced. Recombinant ECL was observed by Western blotting using antisera raised against native ECL.

### Example 14.

30 *In vitro* modulation of C-fibre activity by *Erythrina cristagalli* lectin.

### Materials

Substance P EIA kit was obtained from Cayman Chemical Company (690

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KMS Place, Ann Harbor, MI 48108, USA).

### Method

Embryonic DRG were prepared according to Welch *et al* [Welch MJ, Foster KA. (1999) Embryonic rat spinal sensory ganglia. In: The Neuron in Tissue Culture (Haynes LW, ed), John Wiley and Sons. *IBRO Handbook Series: Methods in the Neurosciences* 18 389-392].

Material was applied between seven and fourteen days post initiation of culture and incubated for 3 days prior to assay. After washing with HBSS-D the substance P release capability of the cells was determined by the following method. Wells were washed twice with low potassium buffer (5mM KCl, 144mM NaCl, 1mM MgCl<sub>2</sub>, 0.4mM glucose, 10mM HEPES (pH 7.4), 2mM CaCl<sub>2</sub>).

Basal samples were then obtained by incubating each well for 5 minutes with 1ml low potassium buffer. Following removal of basal samples cells were stimulated by incubating with 1ml high potassium buffer (40-120mM KCl isotonicity balanced with NaCl) for five minutes.

Substance P immunoreactivity was measured using the Substance P Enzyme Immunoassay Kit manufactured by Cayman Chemical Company (690 KMS Place, Ann Harbor, MI 48108, USA) according to manufacturers' instructions and is expressed in pg/ml relative to a standard substance P curve run in parallel.

*Erythrina cristagalli* lectin was demonstrated to modulate the release of substance P in a dose-dependent manner (see Figure 10). At low doses, release of substance P is slightly enhanced above control release, whereas at high concentrations release of substance P is clearly inhibited. This indicates that *Erythrina cristagalli* lectin is able to modulate the activity of C-fibres by preventing release of a key neurotransmitter.

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**Example 15.**

*In vitro* modulation of C-fibre activity by *Erythrina cristagalli* lectin-protein conjugates

5

*Materials & Method*

The preparation of dorsal root ganglia (eDRG) and assay of substance P release were as described previously.

10

A lectin-protein conjugate of the type described in Example 17 was applied to eDRG and substance P release assessed. Figure 11 is representative of such an experiment and demonstrates that *Erythrina cristagalli* lectin conjugated to another protein is capable of modulating release of substance P from an *in vitro* model of C-fibres.

15

**Example 16.**

*In vivo* modulation of C-fibre activity by *Erythrina cristagalli* lectin.

20

*Method*

Electrophysiological studies of C-fibre activity were conducted in anaesthetized Sprague-Dawley rats essentially as described by Diaz, A. and Dickenson, A.H. 1997 *Pain*. 69, 93-100.

25

Briefly, anaesthesia was induced with 2-3% halothane in 66% N<sub>2</sub>O-33% O<sub>2</sub> and a tracheal cannula was inserted. Rats were placed in a stereotaxic frame and a laminectomy performed to expose segments L4-L5 of the spinal cord. Clamps caudal and rostral to exposed section held the cord rigid and the animals spontaneously breathed while maintained in a state of areflexia with

30

Extracellular recordings of convergent dorsal horn neurons were made with

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parylene coated tungsten electrodes which were lowered into the spinal cord by a SCAT (Digitimer) microdrive to a mean depth of 700 $\mu$ m, corresponding to the main zone of output cells from the cord to the brain.

5 Data were captured and then analysed by Spike 2 software. Selected neurons had a clear short latency (0-20ms) A $\beta$ -fibre evoked response followed by A $\delta$ -fibre response and then C-fibre evoked response (90-300ms) after transcutaneous electrical stimulation (2ms wide pulses at a frequency of 0.5Hz) of the centre of the receptive field. Trains of sixteen stimuli allowed  
10 construction of post stimulus histograms. Any neuronal responses occurring 300-800ms post-stimulus were taken as the post-discharge/after-discharge of hyperexcitable neurons.

230 $\mu$ g lectin from *Erythrina cristagalli* was applied in 50 $\mu$ l and C-fibre activity  
15 observed. Figure 12 is illustrative of data obtained from such an approach and demonstrates the downward trend of C-fibre response, compared to controls, over the time of the experiment.

#### Example 17.

#### *In vivo* analgesic effects of *Erythrina cristagalli*-LH<sub>N</sub>/A(-) conjugates

##### *Materials*

Using site-directed mutagenesis, a mutant of LH<sub>N</sub>/A (LH<sub>N</sub>/A(-)) was prepared  
25 that possessed a tyrosine residue at position 227 in place of the native histidine. This mutant is known in the art to result in a protein that is defective in its endopeptidase activity [Zhou, L., de Pavia, A., Liu, D., Aoki, R. & Dolly, J. O., 1995, *Biochemistry*, **34**, 15175-].

30 LH<sub>N</sub>/A(-) was conjugated to a lectin from *Erythrina cristagalli* according to the method described in Example 11.

### Methods

Intrathecal administration of *Erythrina cristagalli*-LH<sub>N</sub>A(-) conjugate was as described in Examples 5, 6 and 19.

#### 5 Example 18.

*In vivo* modulation of antidromic C-fibre activity by *Erythrina cristagalli* lectin.

#### Materials & Method

10 The effect on antidromic C-fibre activity in response to application of *Erythrina cristagalli* was assessed *in vivo* following similar methodology to that reported by Pinter *et al* [Pinter, E., Brown, B., Hoult, J. R. S. & Brain, S. D. (1999) European Journal of Pharmacology, 369, 91-98], Lambeck & Holzer [Lembeck, F. & Holzer, P. (1979) *Naunyn-Schmiedeberg's Arch. Pharmacol.*, 310, 175-183] and Garret *et al* [Garret, C., Carruette, A., Fardin, V., Moussaoui, S., Peyronel, J-F., Blanchard, J-C and Laduron, P. M. (1991) Proc. Natl. Acad. Sci., 88, 10208-10212].

15  
20 *Erythrina cristagalli* was demonstrated to reduce extravasation induced by antidromic C-fibre activity (see Fig. 13).

25 The neurogenic inflammatory response occurs as a result of neuropeptide release from the endings of stimulated primary afferent neurones. The major neuropeptides involved are considered to be substance P, which acts to increase microvascular permeability, so allowing the exudation of plasma proteins from the blood vessels into the tissues, and CGRP, which is a potent vasodilator, and potentiates the oedema response to substance P. These combined phenomena result in inflammatory oedema formation. Furthermore, neurogenic inflammation is thought to be a component of several disorders and diseases, ranging from sunburn and psoriasis in the skin, to migraine, asthma, and rheumatoid arthritis. This study investigated the ability of

30 *Erythrina cristagalli* to modulate neurogenic inflammation induced by electrical



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stimulation.

All experiments were carried out in accordance with the Animals (Scientific Procedures) Act 1986.

5

Neurogenic oedema formation in the rat hind paw *Erythrina cristagalli* was administered 4hr before the start of oedema measurements. Anaesthesia was induced and maintained by isoflurane. *Erythrina cristagalli* (1mg in 100  $\mu$ l Tyrode's solution) was injected i.d into the innervated paw skin in two rats and Tyrode (vehicle control) injected similarly into two separate rats.

10

The rats were allowed to recover then left for 4hr before oedema measurements were carried out. Rats were anaesthetized for the terminal protocol by intraperitoneal injection of sodium pentobarbitone (Sagatal 60 mg kg<sup>-1</sup>). The tail vein was cannulated to allow the maintenance of anaesthesia with sodium pentobarbitone (15 mg ml<sup>-1</sup> i.v. as required). The ipsilateral hind limb was shaved and the saphenous nerve dissected clear of surrounding tissue. The nerves were then ligated centrally and immersed in mineral oil for the duration of the experiment. Rats were placed on an automatic heating pad to maintain the body temperature at 36-38°C.

15

20

The animals were left for about 20 min to allow a stabilisation period after dissection. The animals then received <sup>125</sup>I-bovine serum albumin (180kBq) and Evans Blue dye (0.2-0.5 ml of 2.5% w/v in saline) i.v. via the tail vein in order to visualize and quantify plasma extravasation in paw skin. The saphenous nerve was then carefully, without pulling, lifted onto a platinum electrode. The nerve was then stimulated (10 V, 1 ms, 2 Hz, 5 min) and plasma was allowed to accumulate for 0-30 min. At the end of the accumulation period, a blood sample was taken by cardiac puncture and centrifuged at 6000 g for 4 min to obtain a plasma sample.

25

30

The animal was killed by anaesthetic overdose and cervical dislocation and

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the skin of the innervated areas of both hind paws was removed and weighed. The gamma emissions from plasma and skin were measured in a multi-channel counter (Wallac, UK) and microvascular extravasation was calculated by comparison to a known volume of blood plasma. The plasma extravasated was calculated and expressed as the volume of plasma per 100 mg tissue for the stimulated and control untreated leg.

The results are shown in Fig. 13. Oedema formation induced via this protocol in previous experiments is normally observed as approximately 30  $\mu$ l plasma /100mg tissue. It can be observed that the rat treated with vehicle produced the expected response. Both paws treated with *Erythrina cristagalli*, produced what may be described as a trend towards an inhibitory effect.

Thus *Erythrina cristagalli* modified neurogenic inflammation induced following electrically-mediated neuropeptide release.

#### Example 19.

#### *In vivo* modulation of C-fibre activity by *Erythrina cristagalli* lectin.

##### *Animals*

Adult outbred mice (MF1) of either sex, weight range 20 to 30g have been used for these studies.

All animals were acclimatised by maintaining them in the room in which the tests are to be carried out for a minimum of 4 days.

##### *Materials & Method*

Test and control substances were administered by the intrathecal route using the following procedure. Mice are anaesthetized by induction with 4% fluothane carried in a 50:50 mixture of oxygen and nitrous oxide with a flow rate of 400-500 cc per minute.

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Once anaesthesia is induced the percentage is reduced to 1.5 to 2% for maintenance. The pelvis of the mouse is located, the fur is clipped around the appropriate area and a small incision (about 5mm) is made in the skin above the spinal column.

5

Test material is injected into the intrathecal space using a 30 gauge disposable needle attached to a 50 $\mu$ l Hamilton syringe with luer fitting. The site of injection was normally chosen to be between lumbar vertebrae 1 and 3. Holding the syringe at an angle of about 20° above the vertebral column the needle is inserted into the tissue to one side of the vertebrae so that it slips into the groove between the spinous and transverse processes. The needle is then moved carefully forward to the intervertebral space whilst decreasing the angle of the syringe to about 10°.

10

15

Once inserted into the appropriate spot a characteristic flick of the tail is often, but not invariably, observed. 5 $\mu$ l of test material is then injected into the intrathecal space and the needle withdrawn. The skin incision is then closed with a single wound clip and the animal placed in a box to allow recovery.

20

Mice have been observed to recover rapidly from this procedure and become fully mobile within two minutes.

25

Pre-injection data was acquired from all animals on the day before test substances are introduced. This pre-test data allows screening of animals exhibiting extreme responses to the various stimuli and allocation to groups such that the mean group latency was equivalent. Response to thermal stimuli (hot plate) was determined 20 hours post injection of test and control substances.

30

#### *Hot Plate*

The equipment is switched on to equilibrate for 15 minutes before tests

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commence. The temperature is normally set at 55°C. Individual animals are placed on the surface of the hotplate and observed closely and the time noted when one hind paw is deliberately withdrawn from the surface.

- 5 At this point the animal is immediately removed from the apparatus. In order to prevent tissue damage due to profound analgesia a maximum duration of 30 seconds is allowed for this test.

10 Fig. 14 illustrates data obtained following application of a range of concentrations of *Erythrina cristagalli* lectin to the spinal cord. Response to thermal stimuli is modified in a dose-dependent manner, indicative of C-fibre modulation.

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CLAIMS

1. Use of a lectin in the manufacture of a medicament for treating a disease or condition resulting from an inhibition or stimulation of C-fibre neuron activity, by modulation of C-fibre neuron activity.
2. Use according to Claim 1 of a lectin which binds to a galactosyl residue.
3. Use according to Claim 1 of a lectin which binds to a glucosyl residue.
4. Use of a nucleic acid sequence encoding the lectin defined in any of Claims 1-3 in the manufacture of medicament for treating a disease or condition resulting from an inhibition or stimulation of C-fibre neuron activity, by modulation of C-fibre neuron activity.
5. Use of a conjugate comprising a first lectin coupled to a peptide or protein wherein said peptide or protein is free of Clostridial neurotoxin enzyme activity, or use of a nucleic acid sequence encoding said conjugate, in the manufacture of a medicament for treating a disease or condition resulting from an inhibition or stimulation of C-fibre neuron activity; by modulation of C-fibre neuron activity.
6. A conjugate comprising a first lectin coupled to a peptide or protein, wherein said first lectin is non-endogenous to humans, and wherein said peptide or protein is free of Clostridial neurotoxin enzyme activity.
7. A conjugate according to Claim 6, wherein said first lectin is non-endogenous to vertebrates.
8. A conjugate according to Claim 6 or Claim 7 wherein the peptide or protein is a second lectin.
9. A conjugate according to Claim 8 wherein the first and second lectins are different.
10. A conjugate according to any of Claims 6-9 wherein the first lectin binds to a galactosyl residue.

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11. A conjugate according to any of Claims 6-9 wherein the first lectin binds to a glucosyl residue.

12. A conjugate according to Claim 9 wherein the first lectin binds to a galactosyl residues and the second lectin binds to a glucosyl residue.

13. A conjugate according to Claim 6 or Claim 7, wherein the peptide or protein is an endopeptidase, or a Clostridial neurotoxin free of enzyme activity.

14. A conjugate according to any of Claims 6-13 wherein the first lectin and/or the second lectin if present is a lectin derivative, said derivative having been modified to remove a carbohydrate group whilst maintaining the ability of the derivative to bind C-fibres.

15. A nucleic acid sequence encoding the conjugate of any of Claims 6-13.

16. Use of a conjugate according to any of Claims 6-14, or use of a nucleic acid sequence according to Claim 15, in the manufacture of a medicament for treating a disease or condition resulting from an inhibition or stimulation of C-fibre neuron activity, by modulation of C-fibre activity.

17. Use according to any of Claims 1-5 or 16 for inhibition of C-fibre activity.

18. Use according to any of Claims 1-5 or 16 for stimulation of C-fibre activity.

19. Use according to any of Claims 1-5 or 16-18 for treatment of a disease or condition selected from pain, psoriasis, inflammation, mucus hypersecretion, rhinitis, erythema, irritable bowel syndrome, headache, asthma, and arthritis.

20. A method of treating a disease or condition resulting from an inhibition or stimulation of C-fibre neuron activity, by modulating C-fibre activity, comprising administering an effective amount of a lectin, or a conjugate according to any of Claims 6-14, or a nucleic acid sequence according to Claim 15, to a patient.

21. A method according to Claim 20 for inhibiting C-fibre activity.

22. A method according to Claim 20 for stimulating C-fibre activity.

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23. A method according to any of Claims 20-22 for treating a disease or condition selected from pain, psoriasis, inflammation, mucus hypersecretion, rhinitis, erythema, irritable bowel syndrome, headache, asthma, and arthritis.

5 24. A method of preparing a conjugate according to any of Claims 6-14, comprising coupling together, optionally via a linker, the first lectin and the peptide or protein.

10 25. A method of preparing a conjugate according to any of Claims 6-14, comprising expressing in a host cell a nucleic acid sequence according to Claim 15, optionally including a linker nucleic acid sequence located within the nucleic acid sequence of Claim 15 to provide a linker molecule between the first lectin and the peptide or protein of the conjugate.

15 26. A pharmaceutical composition comprising a lectin and a peptide or protein, wherein the peptide or protein is an endopeptidase or a Clostridial neurotoxin free of enzyme activity.

20 27. A pharmaceutical composition according to Claim 26, wherein the peptide or protein is an LH<sub>N</sub> fragment of a Clostridial neurotoxin.

25 28. Use of a pharmaceutical composition according to Claim 26 or Claim 27, in the manufacture of a medicament for treating a disease or condition resulting from an inhibition or stimulation of C-fibre neuron activity, by modulation of C-fibre activity.

29. Use according to Claim 28 for treatment of a disease or condition selected from pain, psoriasis, inflammation, mucus hypersecretion, rhinitis, erythema, irritable bowel syndrome, headache, asthma, and arthritis.

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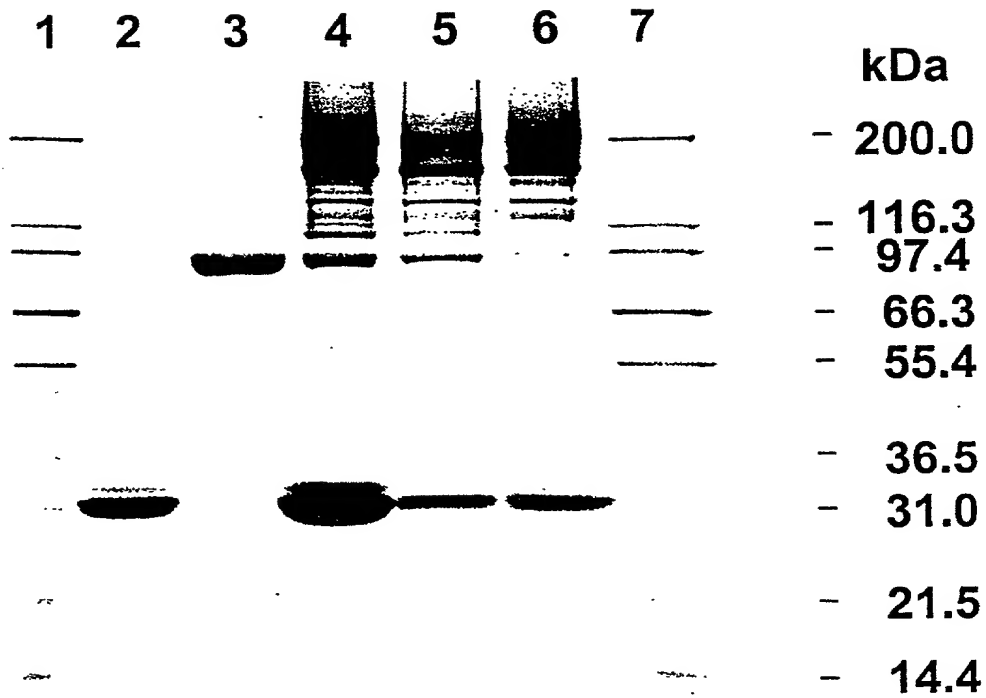


Figure 1.



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Lectins and Lectin Conjugates are Analgesic in a  
Mouse Hot-plate Model

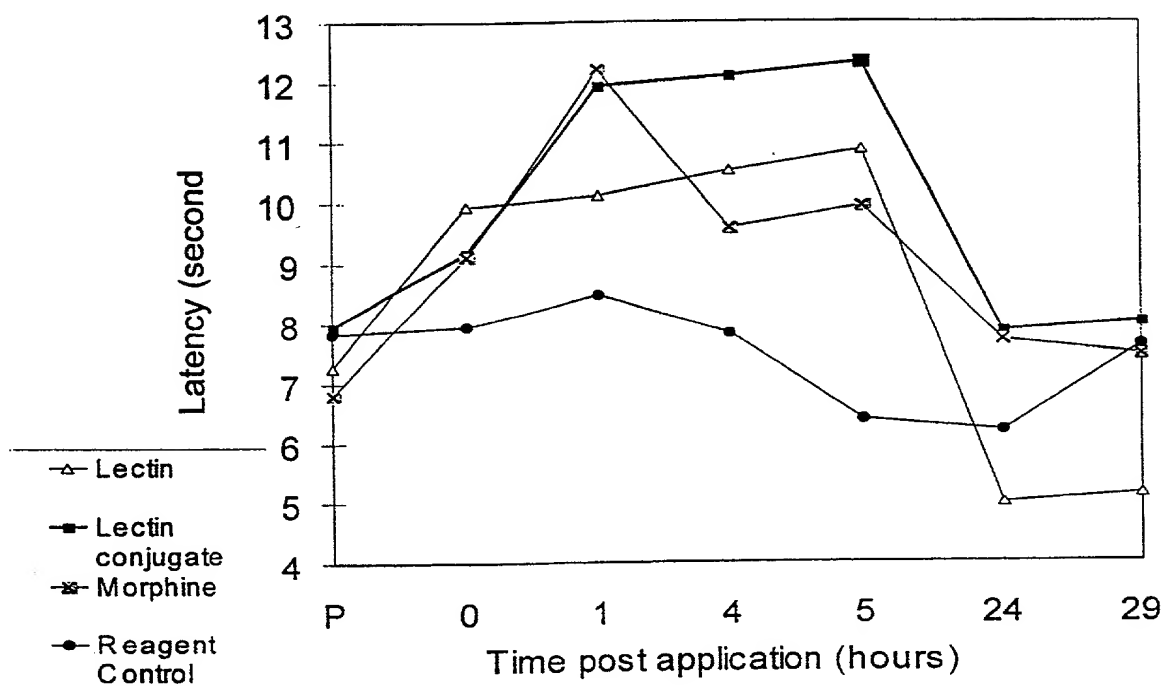


Figure 2

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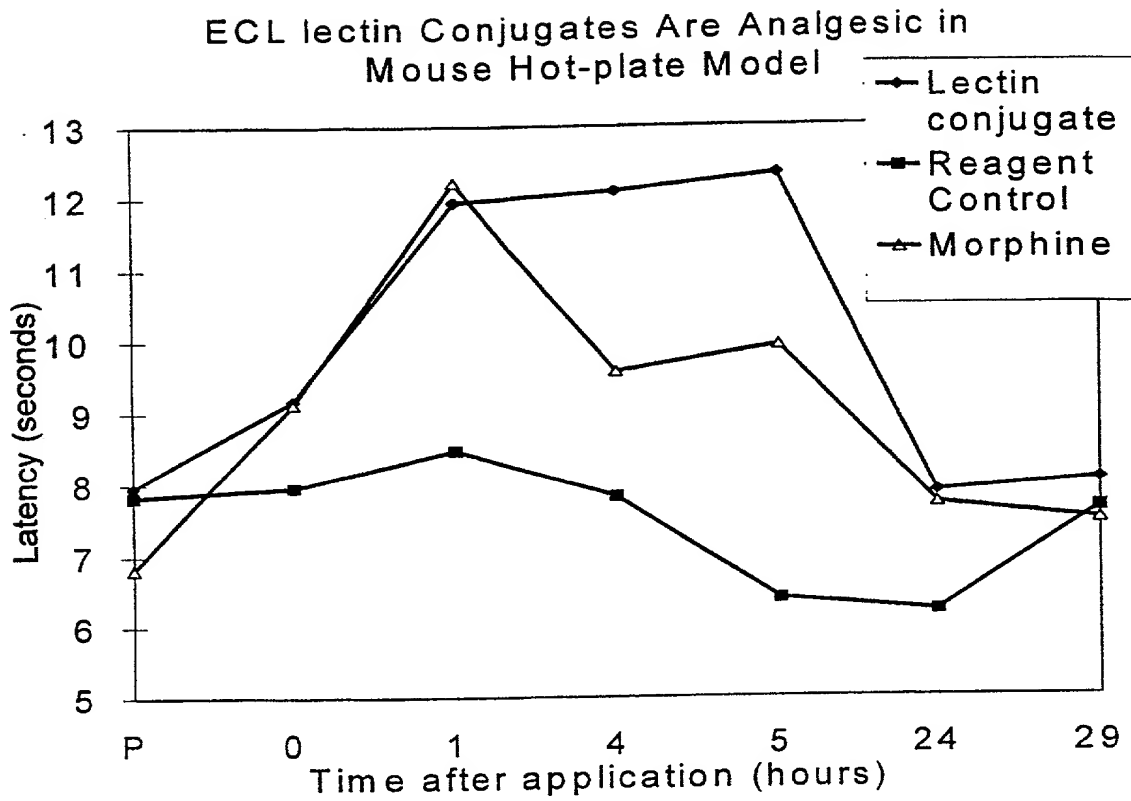


Figure 3

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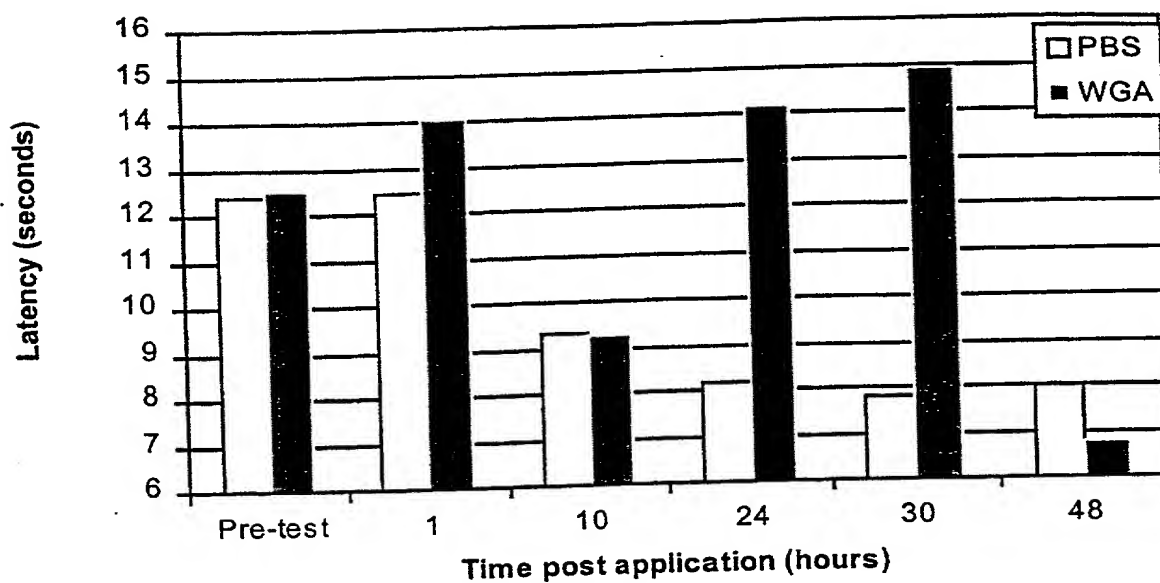


Figure 4.

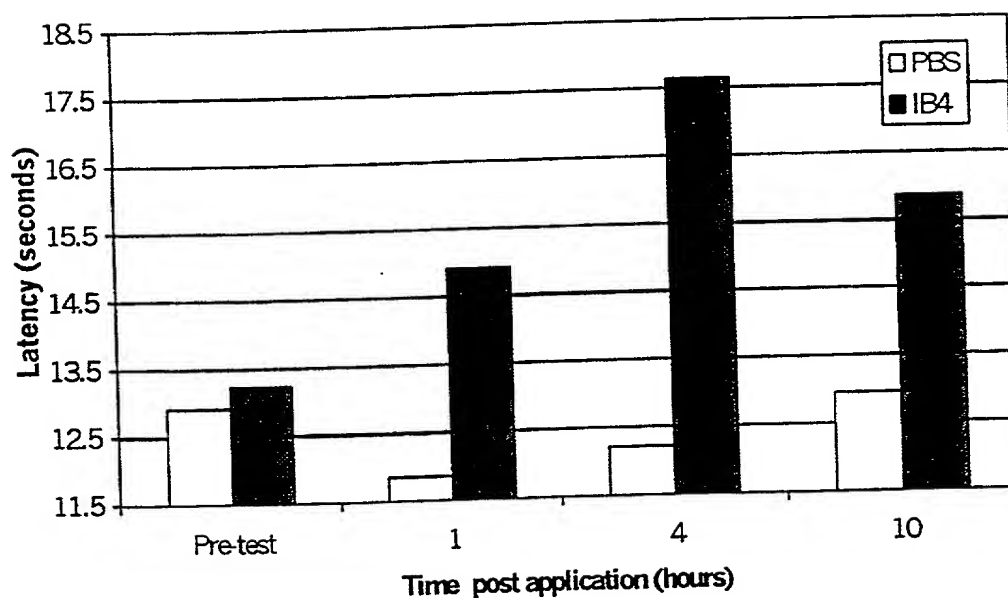


Figure 5.

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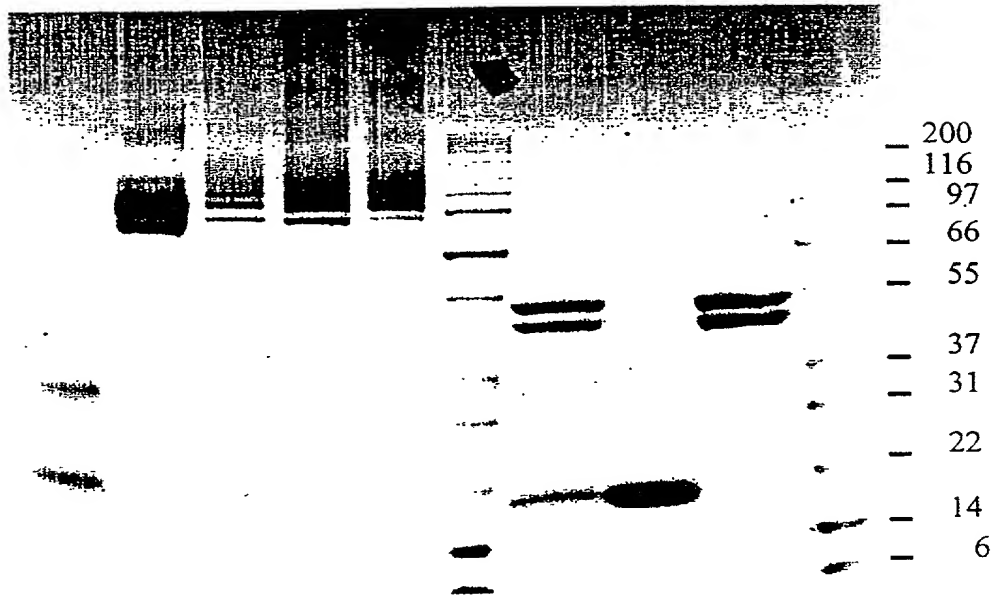


Figure 6.

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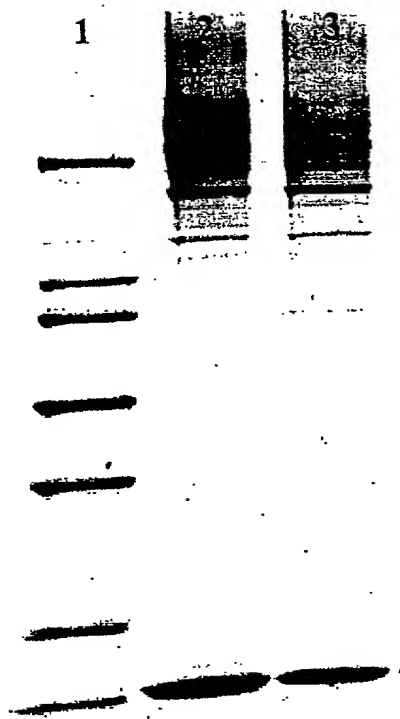


Figure 7.

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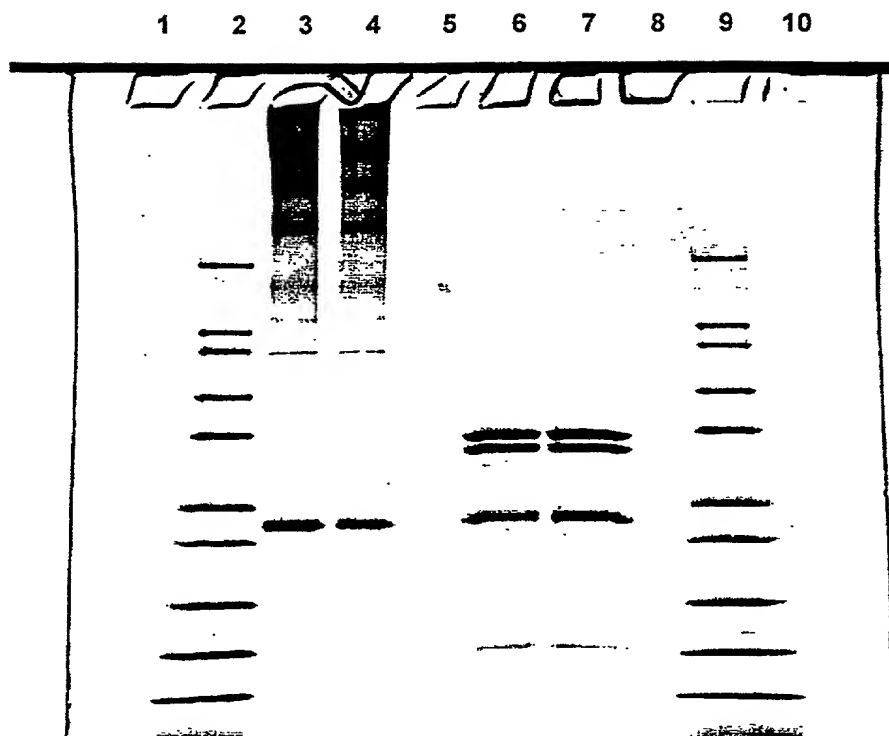


Figure 8.

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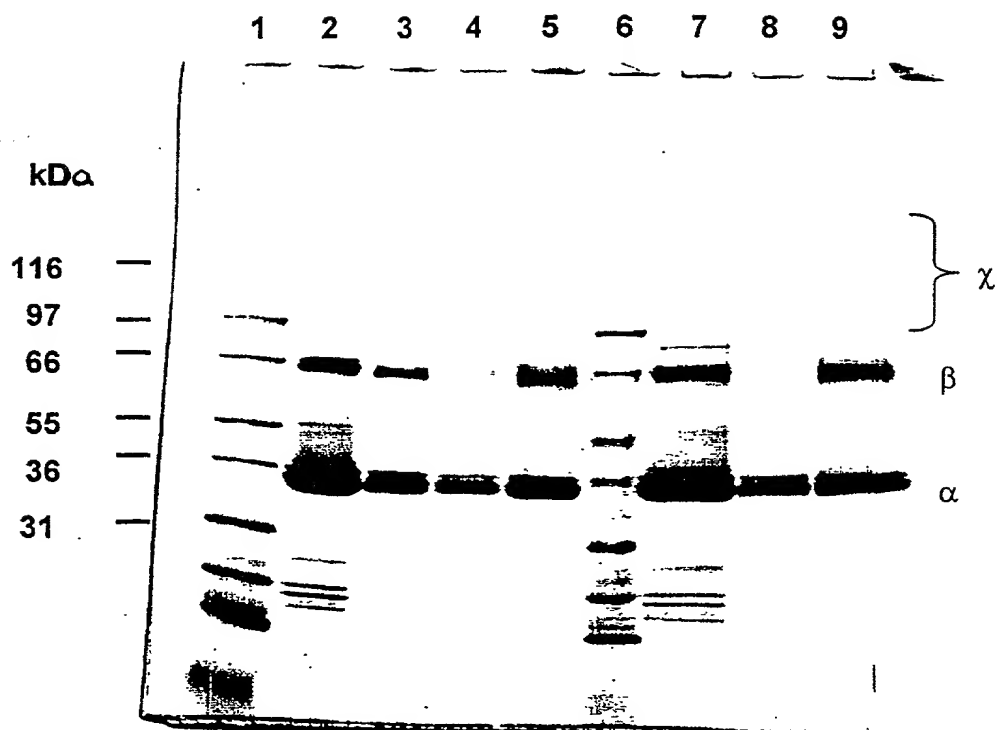


Figure 9.

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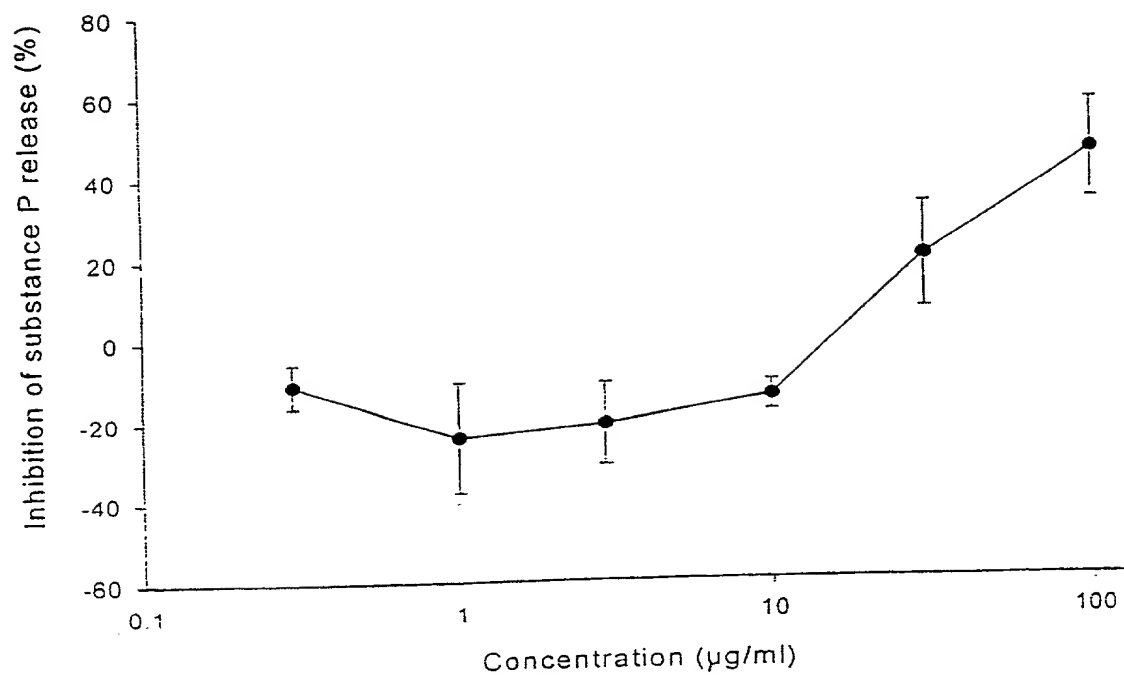


Figure 10.



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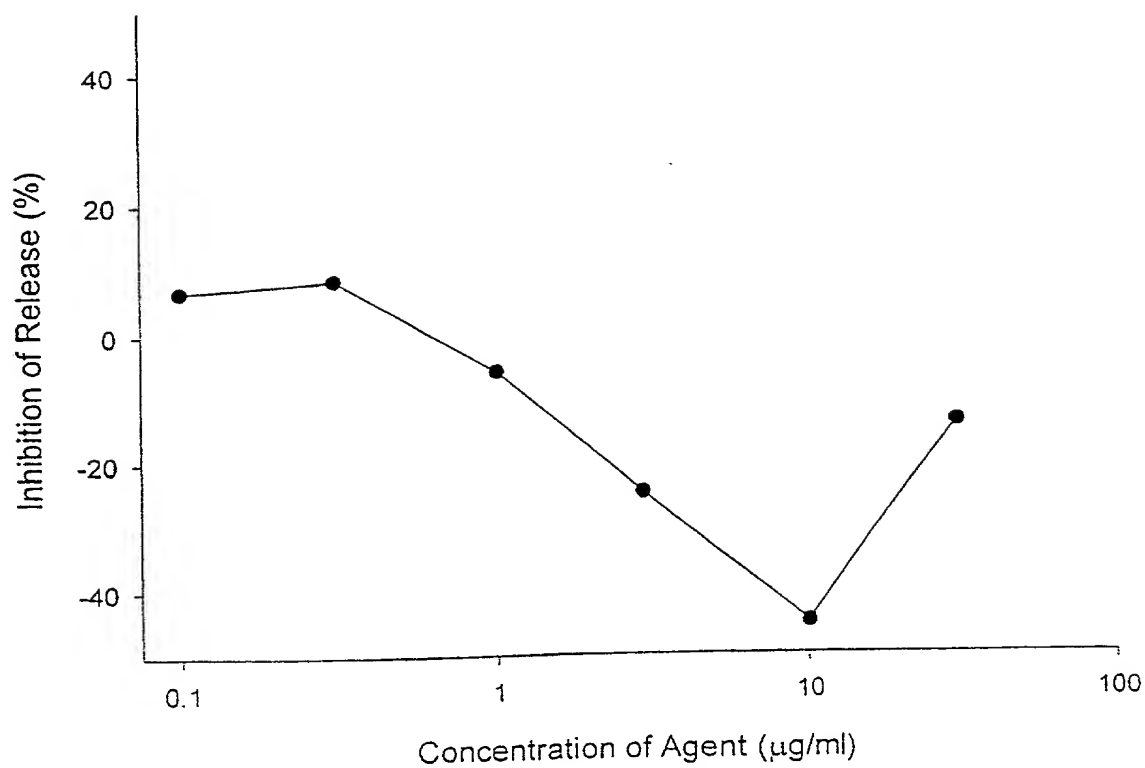


Figure 11.

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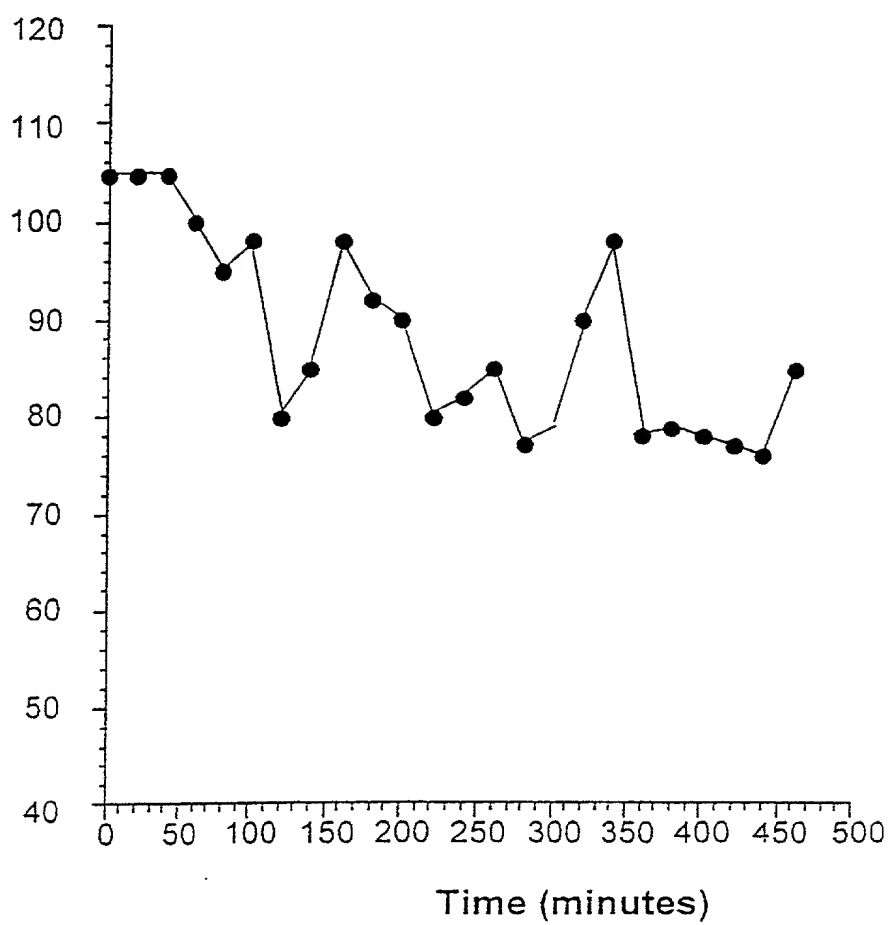
C-fibre Response (%  
of control)

Figure 12.

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Rat	Pretreatment (-4h)	Paw	$\mu$ l plasma /100mg tissue
1.	<i>Erythrina cristagalli</i> lectin	Stimulated	18.4
	None	Nonstimulated	4.7
2.	<i>Erythrina cristagalli</i> lectin	Stimulated	17.5
3.	Vehicle (Tyrode)	Stimulated	32.2
	None	Nonstimulated	4.3

Effect of *Erythrina cristagalli* lectin on neurogenic inflammation induced by stimulation of the rat saphenous nerve.

Figure 13

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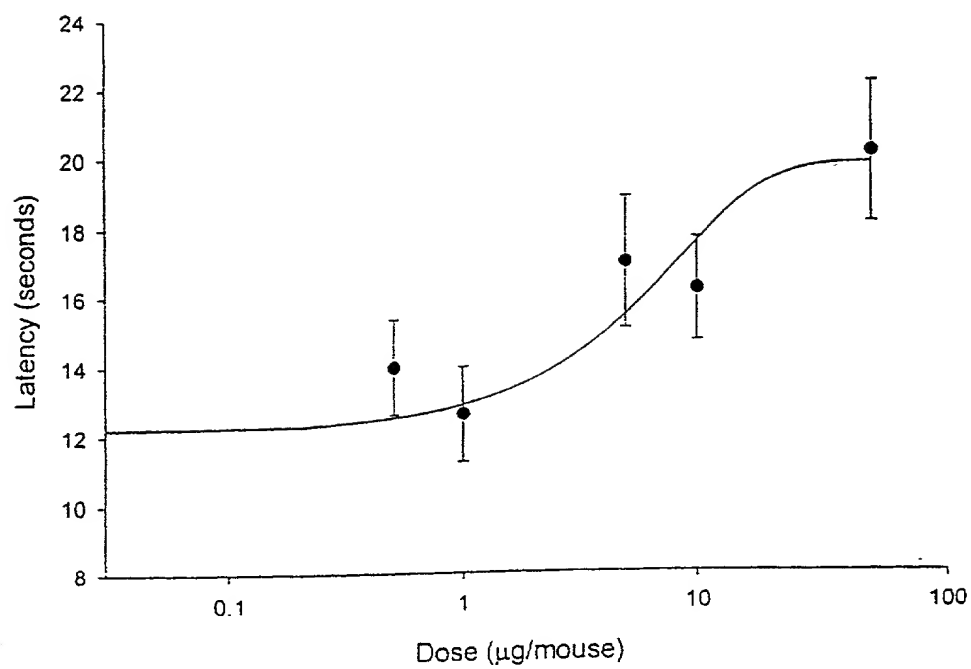


Figure 14

**Combined Declaration for Patent Application and  
Power of Attorney with Delegation**

Docket Number: \_\_\_\_\_

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter that is claimed and for which a patent is sought on the invention entitled Use of a Lectin or Conjugates for Modulation of C-Fibre Activity, the specification of which is attached hereto unless the following box is checked:

- ☒ was filed on 26 September 2001,  
as United States Application Number or PCT International Application Number 09/937,484 and  
was amended on \_\_\_\_\_ (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information that is material to patentability as defined in 37 C.F.R. § 1.56.

I hereby claim foreign priority benefits under 35 U.S.C. § 119(a)-(d) or § 365(b) of any foreign application(s) for patent or inventor's certificate, or § 365(a) of any PCT international application, which designated at least one country other than the United States listed below, and have also identified below any foreign application for patent or inventor's certificate, or PCT international application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application(s)			Priority Claimed
<u>9907429.6</u> (Application No.)	<u>United Kingdom</u> (Country)	<u>31 March 1999</u> (Day/Month/Year Filed)	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No
_____ (Application No.)	_____ (Country)	_____ (Day/Month/Year Filed)	<input type="checkbox"/> Yes <input type="checkbox"/> No

I hereby claim the benefit under 35 U.S.C. § 119(e) of any United States provisional application(s) listed below.

_____ (Application No.)	_____ (Filing Date)
_____ (Application No.)	_____ (Filing Date)

I hereby claim the benefit under 35 U.S.C. § 120 of any United States application(s), or under § 365(c) of any PCT international application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT international application in the manner provided by the first paragraph of 35 U.S.C. § 112, I acknowledge the duty to disclose information that is material to patentability as defined in 37 C.F.R. § 1.56 that became available between the filing date of the prior application and the national or PCT international filing date of this application.

<u>PCT/GB00/01247</u> (Application No.)	<u>31 March 2000</u> (Filing Date)	<u>Pending</u> (Status - patented, pending, abandoned)
_____ (Application No.)	_____ (Filing Date)	_____ (Status - patented, pending, abandoned)

Appl. No. (to be assigned)  
Docket No. ( )

I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith:

Robert G. Sterne, Esq., Reg. No. 28,912; Edward J. Kessler, Esq., Reg. No. 25,688; Jorge A. Goldstein, Esq., Reg. No. 29,021; Samuel L. Fox, Esq., Reg. No. 30,353; David K.S. Cornwell, Esq., Reg. No. 31,944; Robert W. Esmond, Esq., Reg. No. 32,893; Tracy-Gene G. Durkin, Esq., Reg. No. 32,831; Michele A. Cimbala, Esq., Reg. No. 33,851; Michael B. Ray, Esq., Reg. No. 33,997; Robert E. Sokohl, Esq., Reg. No. 36,013; Eric K. Steffe, Esq., Reg. No. 36,688; and Michael Q. Lee, Esq., Reg. No. 35,239.

I hereby authorize the U.S. attorneys named herein to accept and follow instructions from Mathys & Squire, 100 Gray's Inn Road, London WC1X 8AL, ENGLAND, as to any action to be taken in the U.S. Patent and Trademark Office regarding this application without direct communication between the U.S. attorneys and me. In the event of a change in the persons from whom instructions may be taken, the U.S. attorneys named herein will be so notified.

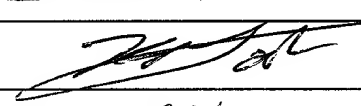
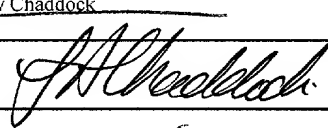
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STERNE, KESSLER, GOLDSTEIN & FOX P.L.L.C.  
1100 New York Avenue, N.W., Suite 600  
Washington, D.C. 20005-3934

Direct Telephone Calls to:

(202) 371-2600

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Full name of sole or first inventor:	<u>Keith Alan Foster</u>	1-a
Signature of sole or first inventor		Date 11 December 2001
Residence:	<u>Salisbury, United Kingdom</u>	GBX
Citizenship	United Kingdom	
Post Office Address:	The Croft, Southampton Road, Whaddon, Salisbury, Wiltshire, SP5 3DX, United Kingdom	
Full name of second inventor:	<u>John Andrew Chaddock</u>	2-a
Signature of second inventor		Date 11 December 2001
Residence:	<u>Salisbury, United Kingdom</u>	GBX
Citizenship	United Kingdom	
Post Office Address:	43 Bouchers Way, Salisbury, Wiltshire, SP2 8RW, United Kingdom	

Appl. No. (to be assigned)  
Docket No.( )

Full name of third inventor: <u>Conrad Padraig Quinn</u>	3-00
Signature of third inventor	Date
Residence: <u>Lilburn, GA 30047, USA</u>	GA
Citizenship: <u>United Kingdom</u>	
Post Office Address: <u>4986 Fox Forest Drive, Lilburn, GA 30047, USA</u>	

Full name of fourth inventor	
Signature of fourth inventor	Date
Residence	
Citizenship	
Post Office Address	
Full name of fifth inventor	
Signature of fifth inventor	Date
Residence	
Citizenship	
Post Office Address	

(Supply similar information and signature for subsequent joint inventors, if any)

# Combined Declaration for Patent Application and Power of Attorney with Delegation

Docket Number: \_\_\_\_\_

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter that is claimed and for which a patent is sought on the invention entitled Use of a Lectin or Conjugates for Modulation of C-Fibre Activity, the specification of which is attached hereto unless the following box is checked:

- ☒ was filed on 26 September 2001,  
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<u>                    </u> (Application No.)	<u>                    </u> (Filing Date)
<u>                    </u> (Application No.)	<u>                    </u> (Filing Date)

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<u>PCT/GB00/01247</u> (Application No.)	<u>31 March 2000</u> (Filing Date)	<u>Pending</u> (Status - patented, pending, abandoned)
<u>                    </u> (Application No.)	<u>                    </u> (Filing Date)	<u>                    </u> (Status - patented, pending, abandoned)



Appl. No. (to be assigned)  
Docket No.( )

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1100 New York Avenue, N.W., Suite 600  
Washington, D.C. 20005-3934

Direct Telephone Calls to: (202) 371-2600

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Full name of sole or first inventor: Keith Alan Foster	
Signature of sole or first inventor	Date
Residence:	
Citizenship:	
Post Office Address:	
Full name of second inventor: John Andrew Chaddock	
Signature of second inventor	Date
Residence:	
Citizenship: United Kingdom	
Post Office Address:	

Appl. No. (to be assigned)  
Docket No.( )

Full name of third inventor: Conrad Padraig Quinn	
Signature of third inventor <i>C.P. Quinn</i>	Date 11 December 2001
Residence: Lilburn, GA 30047, USA	
Citizenship: United Kingdom	
Post Office Address: 4986 Fox Forest Drive, Lilburn, GA 30047, USA	

Full name of fourth inventor	
Signature of fourth inventor	Date
Residence	
Citizenship	
Post Office Address	
Full name of fifth inventor	
Signature of fifth inventor	Date
Residence	
Citizenship	
Post Office Address	

(Supply similar information and signature for subsequent joint inventors, if any)

## POWER OF ATTORNEY FROM ASSIGNEE WITH DELEGATION

Microbiological Research Authority, having a principal place of business at CAMR, Porton Down, Salisbury, Wiltshire SP4 0JG, Great Britain, is assignee of the entire right, title, and interest for the United States of America (as defined in 35 U.S.C. §100), by reason of an Assignment to the Assignee executed on 12 December 2001 of an invention known as Use of a Lectin or Conjugates for Modulation of C-Fibre Activity (Attorney Docket No. \_\_\_\_\_), which is disclosed and claimed in a patent application of the same title by the inventor(s) Keith Alan Foster, John Andrew Chaddock and Conrad Padraig Quinn (said application filed on 26 September 2001 at the U.S. Patent and Trademark Office, having Application Number 09/937,484).

The Assignee hereby appoints the following U.S. attorneys to prosecute this application and any continuation, divisional, continuation-in-part, or reissue application thereof, and to transact all business in the U.S. Patent and Trademark Office connected therewith: Robert Greene Sterne, Registration No. 28,912; Edward J. Kessler, Registration No. 25,688; Jorge A. Goldstein, Registration No. 29,021; Samuel L. Fox, Registration No. 30,353; David K.S. Cornwell, Registration No. 31,944; Robert W. Esmond, Registration No. 32,893; Tracy-Gene G. Durkin, Registration No. 32,831; Michele A. Cimbala, Registration No. 33,851; Michael B. Ray, Registration No. 33,997; Robert E. Sokohl, Registration No. 36,013; Eric K. Steffe, Registration No. 36,688; Michael Q. Lee, Registration No. 35,239; and Steven R. Ludwig, Registration No. 36,203. The Assignee hereby grants said attorneys the power to insert on this Power of Attorney any further identification that may be necessary or desirable in order to comply with the rules of the U.S. Patent and Trademark Office.

The Assignee hereby authorizes the U.S. attorneys named herein to accept and follow instructions from Mathys & Squire, 100 Gray's Inn Road, London WC1X 8AL, Great Britain as to any action to be taken in the U.S. Patent and Trademark Office regarding this application without direct communication between the U.S. attorneys and the Assignee. In the event of a change in the persons from whom instructions may be taken, the U.S. attorneys named herein will be so notified by the Assignee.

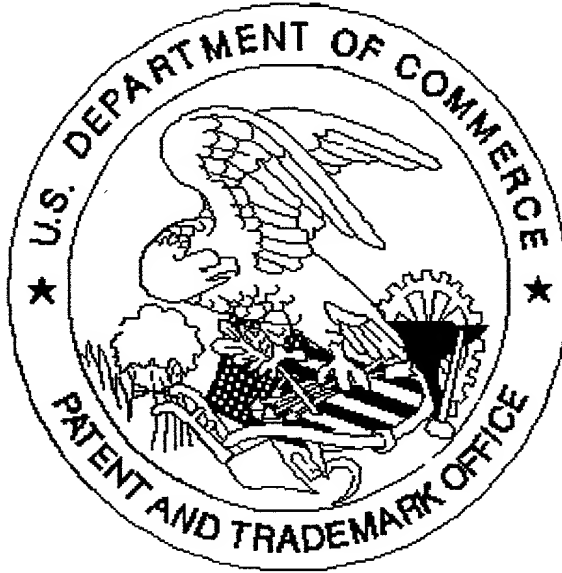
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1100 New York Avenue, N.W.  
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U.S.A.

Direct phone calls to 202-371-2600.

FOR: Microbiological Research Authority  
SIGNATURE: [Signature]  
BY: JOHN M HARKER  
TITLE: SECRETARY MRA (CAMR)  
DATE: 13 December 2001

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